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FOUNDED BY C. E. LINEBERGER

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VITAMINS.*

By C. E. RONNEBERG,

Department of Chemistry—Crane Junior College, Chicago.

Without doubt practically all of us have heard of vitamins in connection with our food or diet. In fact, the subject has been almost forced upon us by the persistence of some food manufacturers in advertising the particular advantages of using their food products as sources of vitamins. Thus the manufacturers of yeast have markedly increased the sale of their product by extensively advertising its advantages as a concentrated source of vitamins. Of course vitamins are absolutely essential in our diet, but nevertheless much that is pure "bunk" has been put out concerning the nature and importance of vitamins, and the so-called advantages of certain preparations as sources of vitamins.

Vitamins can best be described by briefly referring to the manner by which they were discovered. The old idea concerning the essentials needed for an adequate diet was that it should contain water in large quantities; proteins, such as meat, eggs, milk, etc.; carbohydrates, such as sugar and starch in its various forms; fats; and finally mineral matter, such as calcium needed to make bone and iron necessary for the blood. Protein was needed to replace worn out tissue and to supply material for growth. The carbohydrates and fats were energy producing substances; that is, they were consumed by the body by oxidation or burning. liberating energy in the form of heat. Thus the human body was looked upon as a sort of engine, which required fuel in the form of fats and carbohydrates, and in

*This article is a twelve minute radio talk in a popular strain delivered over Station WORD of Chicago.

addition water, mineral salts, and protein matter in order to function properly. In science the unit for measuring quantity of heat is the calorie and the fuel value of various foods when oxidized is quite definitely known. Likewise, the energy requirement of individuals in various lines of physical activity is quite accurately known. Thus a man doing hard physical labor should have food equivalent to about 3500 calories per day while a person doing office work needs from 2000 to 2500 calories per day. According to this early conception the matter of correct diet for any one individual was largely a question of finding out his energy requirements, then selecting a sufficient quantity and variety of food to meet this requirement. A chain of restaurants which can be found in all parts of this country has tried to popularize this conception of a correct diet by stating on their menus the calorie value of all foods which they serve their patrons.

But somehow the matter did not always work out as simply as scientists thought it should. For instance, Hopkins, an English investigator, found that when animals were fed upon a diet of protein, fat, and carbohydrate which had been very carefully purified, and with all necessary mineral matter included, that they wasted away and died. In other words animals cannot live upon highly artificial foods, even though they have the proper quantities of fat, carbohydrate and protein. Hopkins proved that animals consuming even more than enough of this artificial food to take care of all energy requirements ceased to grow and eventually died.

As a result of similar feeding experiments by Hopkins and many others, scientists gradually came to the conviction that there are substances of unknown nature that are absolutely necessary for proper bodily nourishment. These substances occur in such a minute amount in natural foods that no one has yet been able to isolate them in a pure condition, so that their true chemical nature is still unknown. But there seems to be no doubt that they are distinct chemical individuals even though they have not yet been identified by the chemist. They are often referred to as "accessory food factors." or more commonly as the vitamins.

Much of the early work on vitamins was done by Americans, Osborne and Mendel at Yale University, McCollum of Johns Hopkins University, and Steenbock of the University of Wisconsin. These men have been able to prove the existence of

three separate vitamins that are of vital importance. These have been named "fat soluble A", "water soluble B", and "water soluble C", or simply vitamins A, B, and C. Of these vitamins probably vitamin A has the greatest total influence upon our health and vitality. It is often called the growth promoting vitamin. This vitamin occurs in high concentration in butter, egg yolk, milk, and in vegetables such as spinach and tomatoes. If this vitamin is absent from our food, growth is arrested or stunted, especially in children, and there is a weakening of bodily tissues so that there is an increased susceptibility to disease. If it is absent from our food for any great length of time, a characteristic eye disease develops which may result in blindness. During the Great War a severe outbreak of this disease occurred among the children of Roumania because the Austrians had driven off all the dairy cows so that their food was limited largely to corn meal and a soup prepared from bran. The Red Cross by sending in a ship load of cod-liver oil, which contains large quantities of vitamin A, saved the lives of thousands of these suffering children.

Vitamin B is probably the most widely distributed of the vitamins in the parts of plants and animals used for foods. Milk and whole grain cereals contain from three to five times as much as is needed for normal growth. It is present in practically all fruit juices. This vitamin is absolutely necessary for nutrition at all ages, and its lack causes a loss of appetite, general bodily weakness, loss of weight, followed by gastro-intestinal disturbances. The most serious effect, however, is an inflammation of the nerves, or neuritis, known as beri-beri. This disease is common in the Far East where the people subsist largely upon rice. In the rice kernel, the vitamin B is concentrated in the outer covering. In the process of rice polishing, which is done solely to improve the appearance of the rice, this covering is removed and likewise the vitamin. The use of unpolished rice, therefore, is a better procedure when using rice for food. The custom of including fresh fruit as a part of our breakfasts is no doubt due to our instinctive need for vitamin B, which so profoundly affects the appetite.

Vitamin C is also absolutely necessary for general well-being, and in addition prevents scurvy. This is a disease characterized by spongy gums and bleeding from the mucous membranes, and is entirely due to a lack of fresh vegetable food. During the recent World War, scurvy was common among European

soldiers but that no scurvy developed among the American soldiers was due to the fact that canned tomatoes, which contain large quantities of vitamin C was a part of the U. S. Army ration. Many medical men claim that scurvy is much more prevalent than supposed. Children, for instance, often become irritable, flabby and retarded in growth, which is characteristic of incipient or latent scurvy. This condition can be remedied at once by giving vitamin C, say in tomato or orange juice. A diet poor in C also increases the susceptibility to infectious diseases. Thus vitamin C plays a double role in nutrition, to prevent scurvy, and to enable the tissues to resist successfully the invasions of infectious diseases.

More recently scientists have been able to show the existence of at least two more vitamins, known as vitamins D and E. Vitamin D is the anti-rachitic vitamin, or the one that prevents rickets. The essential feature of rickets is a retarded deposition of calcium phosphate in the bones so that they do not develop properly. Children afflicted with rickets sometimes develop bow-legs, because the insufficiently developed bones of the body bend because they are not strong enough to bear the child's weight. Medical men have known for a long time that sunshine and codliver oil, either together or separately would cure rickets and for a long time this seemed inexplicable. The answer seems to be that exposure of the child suffering with rickets to the ultra-violet rays of the sun results in the production of vitamin D in the body, and of course this would function in the same way as vitamin D supplied in the form of cod-liver oil. Vitamin D seems to be the only vitamin which is produced or placed in an activated condition in the body. For this activation the ultra-violet rays of the sun are necessary. Both vitamins A and E affect the ability of the species to reproduce but act independently of each other and both are necessary.

Since the essential need of all the vitamins in our diet has been amply proved, every possible effort should be made to see that the foods we eat contain more than sufficient quantities of all the vitamins at all times. This is especially important since the body is not able to store up vitamins with the exception of A. Vitamins originate in the plant kingdom so that animals are dependent upon plants for their vitamins. Because of this meats are in the main poor in vitamins. They are of course valuable as sources of fats and protein. Probably most of us eat entirely too much meat anyway and we would be

better off if we ate more vegetables and fruits than we do. By taking a great variety of foods including plenty of fresh vegetables, fruits, milk, and eggs, we are sure to obtain ample amounts of all the vitamins. What one food may lack another will supply. Thus whole milk, raw or canned tomatoes, cabbage, orange juice, boiled potato, fresh peas, spinach, and pineapple all contain vitamins A, B, and C in quite large quantities. It is significant that fresh spinach is especially rich in all three vitamins, while canned spinach is only slightly inferior. Whole wheat bread, especially if made with milk is much to be preferred to plain white bread. Butter is rich in vitamins A and D, but contains none of B or C. Eggs contain large quantities of A and B, but none of C. The same is true of cheese. As a result of the extravagant claims of yeast manufacturers, a yeast eating fad has developed the last few years. Yet yeast, while an excellent source of vitamin B contains none of vitamins A and C, so that as a source of all the vitamins it is inadequate. Cod-liver oil contains vitamin A in very high concentration, 250 to 500 times that of butter fat. Because of this it should especially be given to children, not only for its A content but also for its effect in preventing rickets.

Enough has been said concerning the vitamin content of various foods to indicate that if we take a sufficient variety of foods including fruits and vegetables, that there will be ample supplies of fat, protein and carbohydrate, mineral matter, but also of all the essential vitamins as well.

In closing I might mention in a general way the nature of the food an adult should have each day if the diet is to be adequate in all essentials. Each day an adult should have the following:

1. One pint of milk, which contains fat, protein, mineral matter and the all important vitamins.
2. Two servings of vegetables besides potatoes. Potatoes furnish energy, the vegetables mineral matter and vitamins.
3. Two servings of fruits, preferably fresh fruit, though canned fruit is also desirable.
4. One serving of meat, fish or egg. These will supply the needed protein to replace worn-out tissue.
5. At least one serving of a whole cereal, as rolled oats. Highly milled foods or artificial breakfast foods have lost nearly all their vitamin content in the process of preparation and also most of their mineral matter and protein.

6. Something raw, fruit or vegetable, at least once a day. Vitamin C is easily destroyed by heat, hence raw vegetables, as cabbage, and raw fruits, as apples or oranges, will furnish enough of C to promote health.

7. Bread and butter. The bread should preferably be made with whole milk and from whole wheat flour, since it then contains the needed mineral matter, protein, and the valuable vitamins as well. The butter furnishes vitamin A in high concentration.

THE BULLETIN BOARD IN COMMERCIAL GEOGRAPHY.

By Grace A. Robinson,
Cass Technical High School, Detroit.

The pupils cull the articles from the magazines and newspapers as they happen upon them in their leisure reading. The contributions are entirely voluntary, covering any of the subjects of the course. We always have enough clippings to cover the board anew every few days.

The students give a brief review of the most important articles contributed. The headlines of the others are read and the class is at liberty to take the articles from the board at any time that there is a lull in the procedure of the class; during the period of assembly and while the attendance is being taken.

The chief value of this work has been that it connects the course in Commercial Geography with present day interests and makes it a live subject. I like especially to have the students bring newspaper clippings because they come to realize that there is something beside sensational items there; and often their attention is attracted to an article only because they had studied the subject in class and had become familiar with it. The pupils like the bulletin board and willingly contribute to it.

ENGINE MAY SAVE MILLIONS.

American automobile owners can save $400,000,000 annually by using engines that operate at a constant instead of a variable pressure, Prof. H. M. Jacklin of Purdue University has reported to the Society of Automotive Engineers.

Present auto engines operate so that the volume of the gaseous fuel exploded is constant. Prof. Jacklin's experiments were made upon an experimental engine constructed with a movable cylinder-head that was used to reduce the volume of the cylinder as the speed of the engine decreases. This maintained the same pressure within the cylinder at all speeds. No adjustment of spark was necessary.

Gains of up to 50 per cent in miles per gallon might be expected if the new type engine were substituted for the ordinary engine now in use. Fuel bills would be cut a third, according to Prof. Jacklin's computations. Assuming a complete substitution of the constant compression engine in the 20,000,000 cars now running 6,000 miles a year on 20 cents per gallon gasoline, Prof. Jacklin sees the possibility of conserving our natural resources and the national pocketbook to the extent of some four hundred millions annually.—*Science News-Letter.*

TRIGONOMETRIC FORMULAE ENCOUNTERED IN A COLLEGE ENGINEERING COURSE.

By Wm. Herbert Edwards,
Northeastern High School, Detroit, Mich.

What trigonometric formulae will a student most probably encounter in an engineering course in college?

We limit this investigation to the engineering course for two reasons. The first reason is that trigonometry is involved in the subjects required in the engineering courses in colleges. The reason for not including other college courses is that the only trigonometry encountered by students other than engineering students would be in college algebra, analytics, and calculus. There is no reliable way of determining the probability of these other students taking any of these branches of higher mathematics because of the varied mathematical requirements of different schools and of different courses.

Method of Investigation.

The method of investigation consisted of two steps. First, we selected the probable college courses in which trigonometry would be involved. Second, we analyzed the contents of text books on the college courses selected.

Applications of Trigonometry.—First of all, trigonometry is "mathematical" and therefore we should expect to encounter some trigonometry in the mathematics required of engineering students. The mathematics required of these students comprises college algebra, analytics, and calculus.

In the second place trigonometry is concerned with quantitive line, space, and place relationships. Hence, we should expect to find applications of trigonometry in situations wherein distances, areas, volumes, and angles are required to be known. Such situations occur in the college engineering courses in the theory of electricity, in the elements of mechanics, and in surveying.

The applications of trigonometry in college courses, then, should be encountered chiefly in higher mathematics (college algebra, analytics, and calculus), theory of electricity, elements of mechanics, and surveying.

Getting the Facts.—We analyzed the contents of the subject matter of the discussions and of the illustrative problems in text books in each of the four fields of application of trigonometry in college subjects. The group representing higher mathematics

contained one college algebra, one correlated mathematics for junior colleges, one analytic geometry, and two books on calculus. There were five books each representing electricity, mechanics, and surveying. Twenty books were analyzed in all.

The analysis technique was simple. We noted each trigonometric formula which was mentioned in the subject matter or in the illustrative problems in the texts analyzed. Only formulae that were required to be known to understand the subject matter or problem were counted. For example, if a text discussion mentioned the "Sine Law" as being used for finding an unknown distance, this would be counted one occurrence of this formula. A knowledge of how to find distances by the Sine Law does not necessarily require an understanding of the Sine itself. Consequently, in this example, Sine Law only is counted as having occurred once.

Discussion of the Results.

Characteristics of All Fields.—The first fact that the data reveals is that 70% of all occurrences of all formulae were distributed among six formulae (Table I). These formulae were sine A, having 24.1% of all occurrences of all formulae, cosine A, 23.4%, tangent A, 10.8%, radian, 5.5%, tangent $A = \frac{\text{sine } A,}{\text{cosine } A}$ 3.9%, and $\text{sine}^2 A + \text{cosine}^2 A = 1$, 3.5%.

Characteristics of Each Field.—A second fact that is revealed by this investigation is that the formulae representing at least 70% of all occurrences of all formulae in one field may not be the same formulae comprising 70% of all occurrences in another field of application of trigonometry (Table I). For example, the formulae whose frequency of occurrence totalled 70% or more in the higher mathematics group were cosine A, 17.5%, sine A, 13.4%, $\text{sine}^2 A + \text{cosine}^2 A = 1$, 7.7%, tangent A, 7.3%, $\text{tangent } A = \frac{\text{sine } A}{\text{cosine } A}$, 6.4%, $\text{cosine } 2A = 1 - \text{sine}^2 A$, 5.1%, $\theta = \text{sine}^{-1}\frac{b}{r}$ etc., 4.8%, $\text{sine } 2A = 2 \text{ sine } A \text{ cosine } A$, 3.5%, $\text{secant } A = \frac{1}{\text{cosine } A}$, 3.2%, and functions of $\theta \pm n\theta$, 3.2%.

In the field of surveying the formulae were sine A, 26.4%, cosine A, 17.6%, tangent A, 16.0%, sine law, 7.2%, and cosine law, 5.2%.

The corresponding formulae in the field of electricity were sine A, 33.9%, cosine A, 25.5%, and tangent A, 16.1%.

The applications in mechanics whose occurrence totalled 70%

Tabulation of Results.

Table I.

Trigonometric Formulae Comprising at Least 70 Percent of All Occurrences in Twenty College Engineering Text Books.

All Twenty Texts	Five Higher Mathematics Texts	Five Surveying Texts	Five Texts on Electricity	Five Texts on Mechanics
1. Sine A 24.1%	Cos. A 17.5%	Sine A 26.4%	Sine A 33.9%	Cos. A 28.8%
2. Cosine A 23.4%	Sine A 13.4%	Cos. A 17.6%	Cos. A 25.5%	Sine A 28.1%
3. Tangent A 10.8%	$\text{Sine}^2 A + \text{Cos.}^2 A = 1$ 7.7%	Tan. A 16.0%	Tan. A 16.1%	Tan. A 9.0%
4. Radian 5.5%	Tan. A 7.3%	Sine Law 7.2%		Radian 8.4%
5. $\text{Tan } A = \frac{\text{Sine } A}{\text{Cos. } A}$ 3.9%	$\text{Tan. } A = \frac{\text{Sine } A}{\text{Cos. } A}$ 6.4%	Cos. Law 5.2%		
6. $\text{Sine}^2 A + \text{Cos.}^2 A = 1$ 3.5%	$\text{Cos. } 2A = 1 - 2\,\text{Sine}^2 A$ 5.1%			
7.	$\theta = \text{Sine}^{-1} \frac{b}{r}$ 4.8%			
8.	$\text{Sine } 2A = 2\,\text{Sine } A\,\text{Cos. } A$ 3.5%			
9.	$\text{Sec. } A = \frac{1}{\text{Cos. } A}$ 3.2%			
10.	Functions of $\theta \pm n\theta$ 3.2%			
71.2%	72.1%	72.4%	75.5%	74.3%

TABLE II.

Total Number of Occurrences of all Trigonometric Formulae in Twenty College Engineering Text Books.

	Occurrences	Percent
Five Higher Mathematics Texts	314	36.7
Five Texts on Mechanics	299	35.0
Five Surveying Texts	125	14.6
Five Texts on Electricity	118	13.7
	856	100.0

TABLE III.

Total Number of Different Trigonometric Formulae Encountered in Five College Text Books in Each of Four Different Fields of Application of Trigonometry.

	Number of Formulae
Five Higher Mathematics Texts	41
Five Texts on Mechanics	23
Five Surveying Texts	19
Five Texts on Electricity	13

or more were cosine A, 28.8%, sine A, 28.1%, tangent A, 9.0%, and radian 8.4%.

Total Occurrences in Each Field.—A third fact disclosed by this research is that the number of occurrences of all formulae varied in each field (Table II). In higher mathematics we found 314 occurrences of trigonometric formulae. The number of occurrences in mechanics was 299, in surveying 125, and in text books on the theory of electricity 118.

Total Number of Formulae Used in Each Field.—The fourth fact revealed by an analysis of the data gathered in this study is that each of the four fields varied in the number of different formulae employed (Table III). In the text books on higher mathematics we found 41 different trigonometric formulae, 23 different formulae were found in mechanics. Surveying contained 19 different formulae. The number of different formulae found in texts on the theory of electricity was 13.

CONCLUSIONS.

In answer to the question propounded at the beginning of this discussion, we have these facts:

1. The student entering an engineering course will probably encounter the greatest number and variety of trigonometric formulae in higher mathematics. A less number and variety of formulae will be encountered in mechanics, surveying, and electricity in this order.

2. The student can reasonably expect the formulae for sine A, cosine A, tangent A, radian, Tangent A $= \dfrac{\text{sine A,}}{\text{cosine A}}$ and $\text{sine}^2\text{A} + \text{cosine}^2\text{A} = 1$ to comprise approximately 70% of all occurrences of trigonometric formulae that he will encounter in a college engineering course.

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LIGHTNING AND THE LIGHT-ACTIVE RECEIVER IN TELEVISION.

By JOHN MILLS,
Author of "Within the Atom."

In a television system there must be complementary to the light-sensitive transmitter, or electrical eye, a light-active receiver, just as in telephony a receiver is complementary to the transmitter. This must give forth light in response to an electric current; and the intensity of the emitted light must be directly proportional to the current. Then, whatever light the electric eye sees may be recreated, and all the variations in the original illumination faithfully reproduced.

For television it is also necessary that the light-active device shall perform instantaneously in accord with its controlling current. An ordinary electric lamp-bulb would not serve because an appreciable time must elapse after the current is turned on before the filament heats enough to glow; and when the current ceases, the light itself does not stop at once but fades out gradually. An instance in nature, where light instantaneously accompanies the current which causes it, is found in the lightning flash. The same phenomenon, on a smaller scale and much controlled, is utilized in the design of the light-active element for a television system.

Lightning is an action of electrons, a readjustment of their positions as natural as that of molecules of water flowing down hill. However the water gets up hill, the tendency is for it to run down and seek the stability of sea level. Whenever in any body the numbers of protons and electrons are not equal it is natural for shifts and readjustments to occur until the uncharged condition is attained. The readjustment must frequently wait a suitable condition, just as water held behind a dam seeks its level only when the gates are open to the sluice-ways or the dam breaks.

When a cloud and the earth are oppositely charged there is the possibility of a lightning discharge during which each will become more nearly normal. Between them is an atmosphere of molecules of air—and also, curiously enough, wandering freely and alone through the relatively vast spaces between molecules, a few electrons. Of the air molecules most are normal and uncharged, but some by capture of a wandering electron have become negatively charged—"ions" they should there-

fore be called; and these ions will also be attracted toward any positively-charged body.

Electrons and negatively-charged ions, therefore, move toward earth or cloud, depending upon which is positively charged. How close the latter are and how large their charges determine the violence with which the electrons and ions plunge through the atmosphere. Their progress is much impeded for they must dodge or jostle their way past the enormously greater number of neutral molecules, which pursue only haphazard motions, uninfluenced by the charges on cloud or earth. Their progress is like an automobile in city traffic. It may have considerable ability to accelerate, but if it can travel only a few feet before it must avoid another car, it can never get up to the higher speeds which would permit a serious crash. Given greater ability to accelerate, however, it may even in such short distances reach dangerous speeds.

This is the situation under which lightning occurs. As the charges on earth and cloud are augmented, or one swings closer to the other, the possible acceleration for the electrons and ions is increased. A damaging collision may then occur in which an electron will be knocked off from a neutral molecule. The wrecked molecule is thereby divided into a free electron and a positively-charged molecule, or ion, as it should then be called. The free electron immediately takes up the same course as the others; and the newly-created positive ion, subjected to the electrical forces, starts off in the opposite direction.

Traffic becomes dangerous. With each collision two more reckless drivers are created. Their number grows with enormous rapidity. The normal condition of the atmosphere breaks down; electrical particles stream towards cloud and earth; and the phenomenon known as "lightning" is said to have occurred.

The presence between earth and cloud of a current-carrying stream of molecules which have lost electrons means the possibility of another kind of collision—a collision of such a positive ion with an electron moving in the opposite direction. The two rush violently together; and the electron accepts a place among the planetary electrons of the molecule. In this return to the normal condition of an uncharged molecule there is given off some of the excess energy represented by the violent motion of the combining particles. A flash of light occurs; of which the color and intensity depend upon the position

in the molecule which the neutralizing electron assumes.

In ordinary atmosphere to accelerate electrons, and the casual ions, to such destructive violence as in a lightning flash, enormous charges are required—voltages, in other words, larger than those to be obtained by laboratory appliances, except under either of two conditions. If the separation between positive and negative bodies, represented in lightning by cloud and earth, is small then relatively small voltages are required to produce a spark discharge. This condition is one easily met and is basic to the operation of spark plugs in gasolene engines. On the other hand, if the voltage is relatively low compared to that in lightning, but if the atmosphere is so rarefied—the traffic so thin, in the words of an earlier simile—that the electrons and ions can accelerate to destructive speeds, then a discharge can occur and it will be accompanied by light for the same reasons as in lightning. To bring about this condition, atmosphere of the desired rarefaction is sealed in a glass tube and two electrodes are provided between which discharge may occur.

Such a device, specially designed, constitutes the light-active receiving element in the television system developed in Bell Telephone Laboratories. A sealed glass-tube contains a rarefied atmosphere of neon—a chemically inert gas which is prevalent in small quantities in the earth's atmosphere. Wires leading through the glass connect with metal plates—the bodies between which the miniature lightning is to occur. A considerable voltage is required between these metal electrodes but the glowing discharge will occur and continue as long as such a voltage is applied. Further, and of great importance in its application to television, its brightness after sufficient voltage is applied to make it glow depends directly upon the further increase of the voltage. The tube is therefore kept glowing by a local source of voltage and changes in its brilliancy follow directly those additions of voltage which are transmitted from the distant electrical eye.

Professor H. J. Muller, winner of the American Association One Thousand Dollar prize, found that by treating fruit flies with X-rays the genes are so affected that mutations occur 150 times as often as in nature.

SHALL BIOLOGY STUDENTS DRAW OR NOT?

By Ward L. Miller,
Grove City College, Grove City, Pa.

For several years past the writer has been requiring of his students in college biology (the general course) the same kind of laboratory study and the same kind of records that have customarily been required in other colleges and in most high schools where biology has been taught. It has been necessary for the student to first study and compare forms, and to observe and experiment with processes; then to record his findings and conclusions in a notebook which, at the end of a term or a semester, has been awarded a laboratory grade. Into the notebooks have gone sketches of systems, organs and tissues, diagrams of apparatus and answers to questions designed to bring out relationships between structure, function and adaptation. Valuable as this method may be, it does have some very obvious and quite serious defects.

In the first place students, contrary to repeated instructions, persist in regarding the drawing as the most important part of the laboratory exercise. A person's standing in the course is too often estimated, by fellow students, on the art in his notebook, and his progress throughout the year is invariably measured by the number of drawings he has completed. Of so much importance is the drawing and of so little importance is anything else in the laboratory that a picture copied, either in entirety or in part, from a textbook or from a notebook of the preceding year is thought to fulfill the requirements equally as well as an original drawing, made directly from nature. In fact a copied drawing is regarded as a much better risk for a grade than is an original one if the former contains more detail than the student can see in his actual materials. Even the records of students who are anxious to do strictly honest work show the influence of idealized figures in text and reference books. Actual discovery and thorough comprehension seem to be of less significance, from the student's point of view, than is the preparation of a complete picture which may draw a good grade.

In the second place students use more than half of the laboratory time for drawing pictures of what they have seen in less than half the time; in other words they spend less time in learning than they do in recording what they have learned. While much may be said favorable to the drawing as an instrument for

fixing a principle in mind so that it can be easily and accurately recalled, little or nothing can be said for it as an instrument for revealing or explaining anything new. When, after having made an observation, a person is just ready to draw, he has already learned all that he is going to learn from that observation; the mere exercise of drawing can give him no further information, no more thorough understanding, and no more nor better applications of a principle. Of course research students and those preparing for research must know what and how to draw, for they must use drawings for transmitting to other people the new things they will discover. But none of the elementary students are research people, and only a small minority of them will ever come to that stage; to put the entire class through manual work that is to benefit fewer than one-fourth of them is, to say the least, questionable pedagogy. Seen in this light, the labor of drawing pictures takes on the appearance of lost motion—of effort without equal return. The excuse for requiring this lost effort seems on the surface to be, either that the teacher must teach the way he has been taught, or else that, being unable to devise sufficient investigation work to fill the time, he must pack the laboratory exercise with enough drawing work to keep restless minds occupied.

Finally, because so much of the laboratory time is used up in making drawings, it is impossible to cover as much of the field of biology in a single year as one-year students ought to cover, and of course the majority of students in the general course are one-year people. It was hoped, then, that in casting about for a new method of laboratory procedure one might be found, or else evolved, which, while retaining the good features of the old system, would lack the defects mentioned above. It was hoped that the new system would place emphasis not on drawings, but on the careful study which must precede drawings; that it would allot most of the time not to the recording of a discovery, but to the making of that discovery; that it would permit investigation in a field not narrowed to the needs of a special student, but broadened to the needs of the general student who seeks usable information and culture. It was hoped further that the new system might destroy the certainty among biology students that a skillful artist has an unearned advantage over everyone else in the laboratory, whether he learns any biology or not; that it might neutralize all incentive to copy figures from other students or from books; that it might provide for more attention of

instructors to individual students; and that it might establish a more immediate check on students' work, making possible a correction of error as soon as the error is made rather than at the end of a term or semester.

A new method of laboratory procedure was finally worked out which seemed to promise the desired ends, and it was substituted last year for the old and defective system. The new system possesses two main features which are, at least mechanically, independent of one another and which, in view of the criticism that is to follow, need to be considered separately here.

The first of these features, and probably the newer of the two, is the providing of each student, at the beginning of a laboratory period, with a complete set of prepared drawings for the work of that period, these to be labeled and handed in later as a record of the day's findings. The original drawings were made with greatest care and accuracy by the instructor and two of his assistants; small objects were represented sufficiently enlarged to make important details stand out with prominence, careful measurements of macroscopic objects were made so that correct proportions could be built into the drawings, and microscopic objects were drawn with the aid of a camera lucida. In every case the originals were made from actual laboratory and field materials and were idealized not at all. These first drawings were next traced on stencil sheets, the page numbers, figure numbers and titles were added with a typewriter, and then enough copies were printed with a stencil duplicating machine to supply the class.

The student's task is to observe, to compare and to experiment with forms and processes, just as in any ordinary laboratory program, and to answer questions given for the purpose of bringing out facts which a drawing cannot show. But he does not have to draw any pictures; rather he needs only to label and perhaps to color an accurate drawing which has been furnished him and which agrees with the specimen he has been studying. The drawing comes to be looked upon, then, as the record of a study rather than the study itself; it takes on the aspect of an outline map for a history course or of a conveniently ruled sheet for a bookkeeping course. The drawing now is not worth a grade because the student has not prepared it. Only the investigation is worth a grade, while the drawing is but a record of the investigation.

Not only does the new system reduce to its proper level in

student opinion the importance of drawings. It must be obvious that, in demanding only a minimum of manual work, it also provides time for more thorough study and for laboratory conferences, that it makes possible the covering of twice as much subject matter as can be covered under the old system, that it gives to the artistically gifted student no advantage whatever over the ungifted one, and that, finally, it destroys entirely any desire for copying figures from neighbors or books.

The second of the two main features in the new system is the individual laboratory conference, without which the first feature, despite its several advantages, would be a total failure. After completing a study and labeling his drawing, a student is required to take the materials of his experiment—*not his drawing*—before one of the laboratory assistants and there demonstrate, without help, everything he has learned from his investigation. The assistant quizzes him on structures which he must demonstrate, on apparatus which he must exhibit and explain, and on functions, adaptations, interrelations and interpretations which he must think out for himself. For microscopic studies a demonstration ocular is used, an instrument which is equipped with a movable pointer and two eye pieces, and which fits into the upper end of the body tube of a microscope. But the laboratory assistant is more than a mere examiner; he corrects errors in judgment, clears up misunderstandings, points out matters which the student has overlooked, and gives supplementary information whenever it is needed.

Each assistant is furnished with ruled forms on which are to be recorded the results of student conferences. The form has students' names in a column at the left, numbers which correspond with successive laboratory studies in a row at the top, and then, under each number, four ruled columns, three of which are headed by the letters a, b, and c thus:

	86				87				88				89				90			
Name	a	b	c		a	b	c		a	b	c		a	b	c		a	b	c	

The letters a, b, and c stand for three different degrees of seriousness in errors. It is required of an assistant that he write in the three spaces opposite a student's name the *number* of errors

of the respective types which the student makes in conference, and at the close of the day the grade sheets go in to the instructor. It is the latter who awards grades, and these are recorded in the fourth column under each study number on the grade sheet. Grades are based, for the most part, on the assistants' records, but partly also on accuracy and neatness in labeling and coloring of drawings, and on correctness of accompanying notes. Grades are never given, of course, for work that has not first been checked by an assistant.

The conference feature of the new system makes it imperative that a student investigate natural objects and phenomena before he can receive any credit. He receives no recognition at all if he does no more than read instructions and label his drawings, although this very thing was not infrequently done under the old system, drawings having been copied and labeled from books, and turned in for grades. While there can be no doubt that some student may now and then fill in his drawing without having made an honest study of materials, the fact still remains that, before he can receive any credit, he *must* demonstrate his knowledge, or lack of it, to one of the assistants in conference; he does not leave the matter until after he has gone *clear* through it at least once by himself.

A second advantage of the conference feature is that emphasis, which has been removed from the drawing, is placed upon investigation, technic and understanding. Furthermore the conference provides individual supervision and stimulation which are so necessary for adapting a course of training, otherwise rigid, to individual variations in a student body. Finally it provides a means whereby errors in procedure and in judgment can be corrected as soon as they are made, thus cutting to a minimum the time lost in following wrong leads and in reasoning from false premises. In short it may be said for the new system that it either avoids or neutralizes every serious defect that was seen in the old one. And not only this, for it shows at least an equality with, and probably a slight superiority over, the old system in the ease and accuracy with which information can be gained by the students. The number of errors recorded on grade sheets during the past year has been unusually and surprisingly small. This was true even when the instructor substituted in conference now and then for an assistant, and it was by no means a result of leniency on the part of assistants. In view of these facts one of two alternative conclusions seems unavoid-

able: either students learn more about a given subject under the new system than is possible under the old, or else they learn more under the old system than that system is able to reveal to the instructor. In either case the old system must be at fault.

So far only the advantages of the new laboratory system have been discussed; nothing has been said about faults, and of course there are some of those. If one thinks only of the informational end of laboratory exercise he is apt to see few serious shortcomings in the new system; but there is another end to be considered which is equal in importance to the first. This is the disciplinary end, and in attaining this end the new system displays its weakness.

Every student, in high school as well as in college, ought to know what the scientific method is, how to use it, and how to evaluate its results. It is regrettable that young people can go through four years (or worse, eight) of formal education, working exclusively in the humanities and learning wholly from authority rather than from investigation; but it is unforgivable if they go through even an elementary science course without an exposure to the investigation method of learning. Students need the practice of seeing, hearing, feeling, tasting and smelling through sense organs that are uninfluenced by likes, obligations or thoughts of reward. They need the practice of recording their experiences with cold and unfeeling accuracy exactly as the experiences occurred, and uncolored by preconception, whim or probable result. They need the experience of making records immediately upon completion of an observation, leaving nothing at all to a memory that is certain to be faulty. They need to develop, through real experience, an unfailing personal confidence in natural cause and effect and, also through experience, to come to realize that there is no human authority which is infallible. They need to develop the ability to disciminate between demonstrated fact and mere belief, and to see instinctively the superiority of the former over the latter. Even if a student, after leaving school, were never to use the scientific method in solving any of his problems, he ought still to know it well enough to have confidence in it, for sooner or later he will certainly be called on to pass judgment upon the advice of men-on-the-street as opposed to that of physicians, architects, sanitary engineers, animal and plant breeders, eugenists and scientific theologians.

The first criticism to be aimed at the new laboratory system

is that its tendency to teach by authority instead of by original investigation is much too strong. The student is provided with drawings which, he feels confident, are correct in every detail; otherwise they never would have been given out. With this point of view as a starter the student goes about his investigation, looking for something to match the drawing; he continues to look until he finds it, *and then quits.* If the real material lacks anything which the corresponding drawing contains, it is always the material that is wrong; not the drawing. If the material possesses anything which is not included in a corresponding drawing, then the "extra" is not significant; otherwise it would not have been missed by the instructor. Authority is placed in the drawing, then, instead of in nature where it belongs. The new system has indeed removed one kind of emphasis from the drawing, but that kind has been replaced by another which is probably the worse of the two.

A second defect in the new system comes as a direct result of the first; this is the tendency to stifle student originality and initiative, and to give him but little incentive for making judgements of his own. Instead of inquiring about and investigating things which he might find in his studies if he were not so rigidly guided, he is apt to pass them by with the feeling that they mean nothing and that they occur simply without knowable cause. Confidence in his own powers of discernment is, if not vitiated, at least not strengthened a bit, though it ought to be. There was hope, when the new system was first adopted, that differences in detail between object and drawing, due to individual variation, might raise questions in the student's mind as to reasons for the differences, but that hope was realized in only a limited number of cases. The laboratory exercise grew into a rather simple process of verification instead of a process of discovery and application, and as soon as nature had been matched with a drawing the investigation was finished.

A third defect worthy of mention is that the new system permits a student to observe one thing and to let the drawing of a very different thing serve as his record of it. Due to the fact of individual variation among animals and plants, a very faithful copy of one can never be an accurate representation of any other; always there must be disagreement. Such a system can hardly stimulate a student to record his findings as they actually come to him, and insofar as it falls short in this respect it is certainly unscientific.

As the past year progressed and defects in the new system became apparent efforts were made at correction, and so toward the end of the year drawings that were to be distributed in the class were made only in outline with all details left for the student to fill in from his study. This change, as might be expected, was successful in making the student less dependent, or at least in penalizing him for his dependence and his defective point of view; but such gain was at the expense of breadth of field covered. In fact the gain in one direction was just inversely proportional to the gain in the other; a satisfactory degree of independence and true scientific attitude was prohibitive of a satisfactory amount of material.

It should be noted that all the adverse criticism directed at the new system has affected only one of its two main features, viz. the furnishing of prepared drawings to students prior to their study; the other feature has not been touched. Since the two are mechanically independent of one another it should be possible, and doubtless profitable, to drop the defective half and retain the other, using it to supplement the old and discarded system of requiring students to make all their own detailed drawings. By so doing all the disciplinary advantages of the old system would be regained, and nothing would be lost but some economized time and some of the extended field of subject matter. So little would be lost because most of the advantages of the new system are introduced either wholly by the individual conference feature, or else equally by both features. Pitting the old laboratory system, supplemented by the individual conference, against the new system amounts, then, to weighing a limited field of investigation with disciplinary advantages against a broad field without disciplinary advantages. When the matter is reduced to these simple terms it is not difficult to see which "pan of the balance" must go down because of its greater weight in importance.

Surely there can be no doubt that records of observations are a scientific necessity. No one maintains that they are always, or even usually, of any value for reference purposes, but they *are* of incalculable value as training in the scientific method of learning. In order to gain this end, however, records must be made in their entirety by each individual working independently; they must not be furnished to him ready made by the instructor. If student records must be kept then drawings, one of the most concise forms of records, must stay.

A SHORT FOUCAULT PENDULUM.

Prepared under the direction of Professor S. R. Williams.

By L. S. Welty
and
L. D. Strong,
Amherst College, Amherst, Mass.

One who has seen the majestic sweep of the large pendulum hung from the dome of the Pantheon in Paris will never forget the beautiful sight, nor how impressive it was as the pointer underneath the big pendulum bob gradually flicked off the little rim of sand laid in a circle along whose diameter the bob swept. As one watched, he became aware that the path of the pendulum bob seemed to be slowly swinging with respect to the axis of the building in which the pendulum was hung. This phenomenon was explained by saying that the pendulum swung to and fro in a plane and the pendulum maintained this plane of vibration indefinitely while the earth rotated under it. It can be demonstrated by the simple device shown in Fig. 1 that a vibrating pendulum will maintain its plane of vibration even though the support turns on an axis passing through the center of support of the pendulum. In Fig. 1, if the pendulum bob B is set to

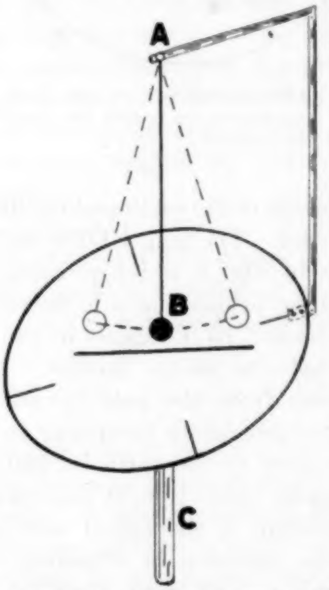

Fig. 1. A pendulum swinging from a point directly on the axis of the turntable will maintain its plane of vibration independent of the rotation of the turntable.

vibrating in a north-south direction it will maintain that direction of vibration as the support, A – C, is turned through 360 degrees or any other angle. Having established this fact, one can imagine a large pendulum suspended directly over one of the ends of the earth's axis and performing in the same way as the pendulum did in Fig. 1. In this case the plane of vibration of the pendulum will appear to rotate with respect to a meridian line drawn on the surface of the earth and return to its original position every 24 hours. The ring CDEF, Fig. 2,

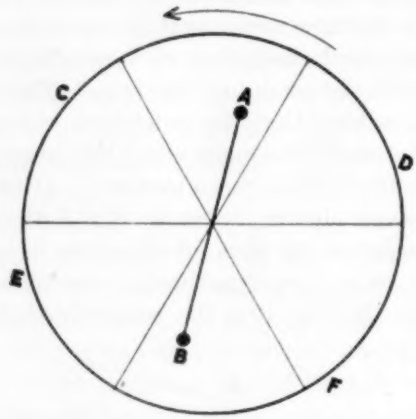

FIG. 2. A PENDULUM SWINGING IN THE PLANE, A-B, ABOVE THE NORTH POLE OF THE EARTH MAINTAINS ITS PLANE OF VIBRATION INDEPENDENT OF THE ROTATION OF THE EARTH.

may represent the surface of the earth and the lines, the meridians converging at the poles. The ring CDEF will also correspond to the circular base in Fig. 1 which rotated. Now we know from astronomical observations that it is the earth which rotates and the pendulum devised by Foucault in 1851 is only demonstrating the fact that the earth rotates. Furthermore, the farther one gets away from the pole toward the equator, the longer it takes for the pendulum to appear to change its plane of vibration with respect to the earth by 360 degrees. At the equator it takes infinite time, i. e., it does not turn at all.

Suppose the pendulum is suspended over point A, Fig. 3. Let AP represent the direction of vibration, which at first is parallel to the meridian. At some time later the earth will have rotated so that A has moved to B. The pendulum will still be vibrating parallel to AP or along BQ, but the meridian

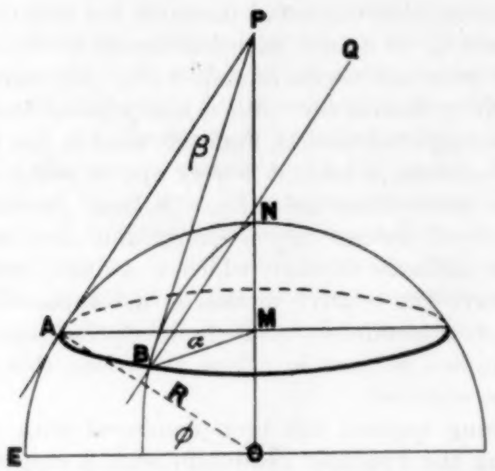

Fig. 3. A PENDULUM SWINGING IN A PLANE PARALLEL TO THE MERIDIAN AT A MAINTAINS THAT PLANE WHEN IT ARRIVES AT THE POSITION, B, GIVING THE APPEARANCE THAT IT HAS TURNED WITH RESPECT TO THE EARTH, WHEREAS IT IS THE EARTH WHICH HAS ROTATED.

has the direction BP, and BQ makes an angle β with BP which is the angle the plane of vibration has turned through with respect to a fixed line on the surface of the earth, while the earth has been turning through the angle $AMB = \alpha$. Now the angle AOE is the angle representing the latitude of A, which is equal to $\varnothing$, where the pendulum is set up, and it can be shown geometrically that approximately the following relations hold between these three angles and the radius R.
By circular measure

$$AB = \alpha \times AM = \alpha \times R\cos\varnothing$$
$$AP = R\tan AOP = R\cot\varnothing$$
$$\text{Also } AB = \beta \times AP = \beta \times R\cot\varnothing \text{ approximately}$$
$$\text{Hence } \alpha \times R\cos\varnothing = \beta \times R\cot\varnothing$$
$$\text{or } \beta = \alpha \sin\varnothing$$

This says that the angle between the plane of vibration of the pendulum and the meridian is proportional to the sine of the geographical latitude. At the equator $\varnothing$ is zero and therefore $\beta = 0$. At the poles $\varnothing = 90°$ and therefore $\beta = \alpha$ or the angle of rotation of the earth on its axis is equal to that of the rotation of the earth with respect to the plane of vibration of the pendulum.

To demonstrate the rotation of the earth is a beautiful experiment, but most of us do not have Pantheons in which to hang them up, not even tall towers or stair wells. The experiment is most successfully carried out with a heavy pendulum bob and a long suspending steel wire as Foucault used in the Pantheon. If a short pendulum is used, it is very apt to swing erratically unless proper precautions are taken. A large pendulum, such as Foucault used, swings very steadily and also has a large amplitude or distance through which it swings, consequently one can observe the relative motion in a comparatively short time. If a short pendulum is used, its motion must in some way be magnified so that in a few vibrations this rotational effect may be observed.

The following method has been employed with success in demonstrating the Foucault pendulum with a suspension wire

FIG. 4. THE PENDULUM BOB, B, IS MADE FROM AN OLD 40 LB. CANNON BALL. A LARGE LAG BOLT, L, HOLDS THE SUSPENSION SYSTEM, S, TO THE CEILING.

a little over nine feet in length, and a forty pound cannon ball for a bob. Foucault's original pendulum had a length of two hundred and twenty feet with a bob of sixty-two pounds. Fig. 4 is a photograph of the bob B and method of attaching the wire, while L and S are the method and means for attaching the upper end of the wire to the ceiling of the room. Fig. 5 gives greater detail to the process of attaching the wire to the bob. The cannon ball B which was a hollow sphere, had a toggle bolt T held firmly in position by screwing the nut N down tightly. The lower end of the wire was inserted in a hole in the upper end of the bolt. In Fig. 4, L is a lag bolt which held

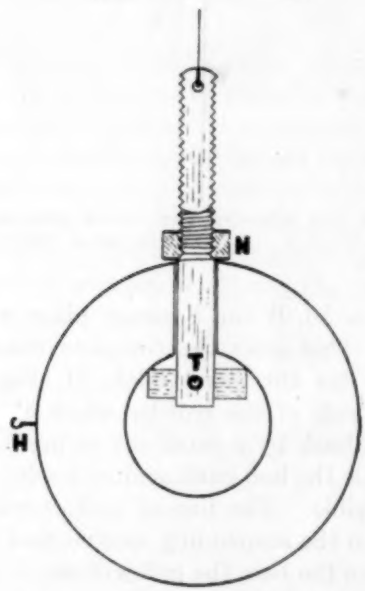

FIG. 5. THE PENDULUM BOB IS A HOLLOW IRON SPHERE WHICH IS ATTACHED TO THE SUSPENDING WIRE BY A TOGGLE BOLT.

an iron plate rigidly against a beam in the ceiling. Fitting tightly into this iron plate was a brass collar S, the details of which are shown in Fig. 6. The wire W fitted snugly into the upper end of the conical hole through the collar, but at the bottom there was some play so that the wire did not have a sharp corner over which to bend each swing it took and thus break quickly. It also gave a form of symmetry for the vibration of the wire to occur with equal ease in any plane whatsoever. The collar S must be made with care to secure this sym-

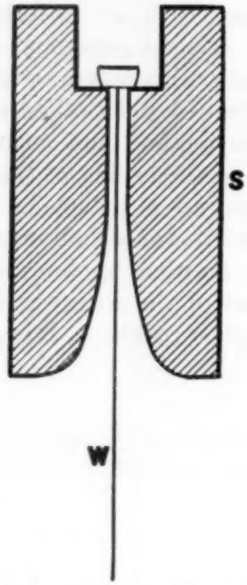

FIG. 6. THE CHUCK FOR HOLDING THE UPPER END OF THE PENDULUM WIRE IS A BRASS COLLAR. A CONICAL HOLE THROUGH THIS COLLAR CARRIES THE WIRE.

metry. About No. 16, B and S guage, piano wire was used in the experiment. This gives the complete construction of the pendulum except for the small hook, H, Fig. 4, which was screwed into one side of the ball by which the pendulum bob could be fastened back by a small silk string. If possible, it is an advantage to tie the bob back against a solid wall, to make it as steady as possible. The line of pull through the hook H must be normal to the suspending wire so that when the string is burned to release the bob, the ball will not be given a rotatory motion either around a horizontal or a vertical axis. This is important for getting steady swings.

With such a short pendulum as this only comparatively small amplitudes of vibration can be used. Since small vibrations would die down quickly, the rotation of the earth with respect to the plane of vibration of the pendulum must be demonstrated in a very short length of time. This means that this relative motion of the earth and pendulum must be amplified in some way. This was done, as shown in Figs. 7 and 8, by an optical device. In Fig. 7 let M be a short focused concave mirror with an aperture of 3 inches and focus of about 5¾ inches. Fig. 7 is a horizontal section of the system cutting the

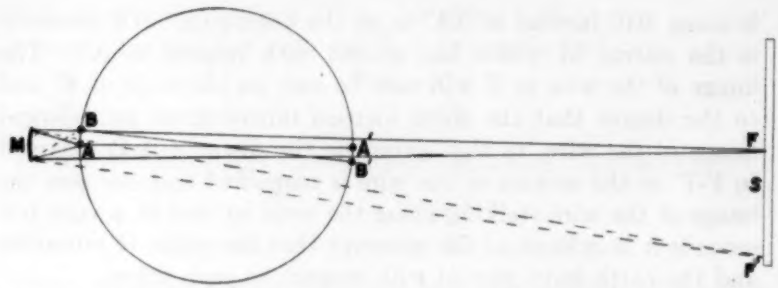

FIG. 7. A SHORT FOCUSED CONCAVE MIRROR, M, THROWS AN IMAGE OF THE WIRE, A, ON THE DISTANT SCALE, S. THE IMAGE OF THE WIRE APPEARS EVERY COMPLETE PERIOD OF THE PENDULUM BUT DISPLACED WITH RESPECT TO THE PRECEDING ONE.

suspending wire about a couple of inches above the bob. A and B and A′ and B′ are successive locations of the wire in its vibrations and as the earth moves. If we assume that the wire at A was heated to incandescence it would send out light to the mirror M which in turn would throw an enlarged image of the hot wire on the scale S at F, when the mirror, wire and scale were properly located. As the earth turns, however, the wire eventually moves to a position B, and the plane of vibration

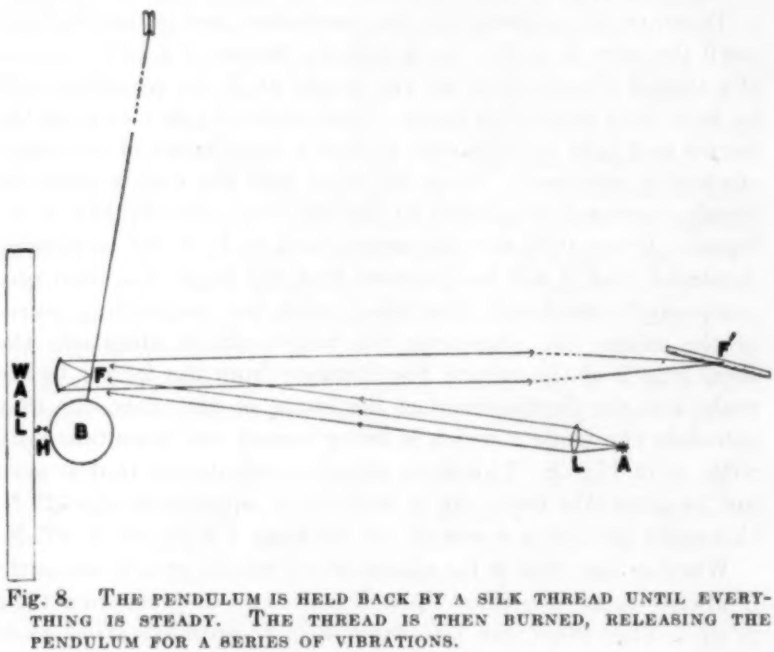

Fig. 8. THE PENDULUM IS HELD BACK BY A SILK THREAD UNTIL EVERYTHING IS STEADY. THE THREAD IS THEN BURNED, RELEASING THE PENDULUM FOR A SERIES OF VIBRATIONS.

is along BB′ instead of AA′ as at the beginning. (Of course it is the mirror M which has moved with respect to A.) The image of the wire at B will now be cast on the scale at F′ and to the degree that the short focused mirror gives an enlarged image of the wire, to that extent is the distance A-B enlarged to F-F′ or the motion of the wire is magnified and one sees the image of the wire stalking along the scale so that in a very few seconds it is evident to the observer that the plane of vibration and the earth have moved with respect to each other.

Now to have the suspending wire heated to incandescence is out of the question, so instead, the shadow of the wire is projected on an illuminated background which is even better. Fig. 8 shows a vertical section of the pendulum and optical system passing through the axis of the pendulum. An arc light at A is placed at the principal focus of the lense, L, which gives a parallel bundle of light rays. When this strikes the mirror, it reflects a large patch of light back on the scale S. When the wire of the pendulum swings so that it comes at about the principal focus of the mirror it cuts out a narrow section of the beam of light, or the shadow of the wire will now be focused on the scale at F. The motion of this shadow will move then, just as the incandescent wire did in Fig. 7.

To start the experiment, the pendulum bob is pulled back until the wire is at F, Fig. 8, and by means of a little loop of silk thread thrown over the two hooks at H the pendulum will be held there until all is ready. Care must be taken to have the mirror and light in alignment so that a good image of the wire's shadow is obtained. When all is set and the bob is perfectly steady, a match is applied to the silk loop and the bob is released. Every time the wire comes back to F, it will be slightly displaced, and it will be observed that the image has been proportionately displaced, depending upon the magnifying power of the mirror M. Knowing the amplitude of vibration, the focal length of the mirror, the distance from the mirror to the scale, and the displacement of the image on the scale, one may calculate the angle β which is being turned out simultaneously with $\propto$ in Fig. 3. This is so simple a calculation that it need not be gone into here. In a latitude of approximately 42° N, this outfit gave as a mean of six readings a latitude of 45° N.

Whether one uses it for quantitative results or not the outfit is always to be depended upon if some care is given to setting it up. This effect can be shown in any ordinary sized room

and affords an excellent set-up for many laboratories where at present this striking experiment is not performed.

AN EVALUATION CHART FOR SCIENCE TEACHERS.*

By W. C. Reusser,

University of Wyoming, Laramie, Wyo.

The following evaluation chart has been used by the writer in the training of science teachers in the University of Wyoming, and is here presented for the value it may have to others engaged in the work of teacher training or to principals, supervisors, and classroom teachers of science. The major topics of the chart are of such a nature that they may be readily observed by a person in making several visits to a class. The minor points under each topic are planned to call attention to specific items in that topic. No claim is made for the completeness of this chart nor that the points selected are in all cases the best ones that could be chosen. In using it the individual teacher or supervisor may wish to add other points or to omit some of those included.

The chart will be found helpful to three groups: (1) College or normal school students who are preparing to teach science may use it as a guide for their observation of the teaching done by more mature and experienced teachers. When used in this way one or two of the major topics should be selected for each day's observation, thus focusing the student's attention on specific points in the teaching rather than on teaching in general. (2) Principals or supervisors may use the chart for making detailed observation of science teaching or for teacher rating. When used as a rating scale columns headed "high," "average," and "low," may be given credit values of 5, 3, and 1, respectively, in order to express the total rating in numerical terms. (3) Classroom teachers of science may use the chart for rating themselves. The valuable point for teachers in rating themselves is to help them to know themselves, to find their own weaknesses, and to correct them.

While this teaching evaluation chart was planned specifically for Science teaching it may, with some slight modifications, be used to evaluate the teaching of other subjects in the secondary school.

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*The writer is indebted to Dr. Thomas J. Kirby, of the University of Iowa, for the form and for much of the material in this evaluation chart.

Teaching Evaluation Chart.

Skill in teaching as shown by the teachers:

	High	Av.	Low
1. Mastery of subject matter.			
a. Does he show a knowledge of the subject taught?			
b. Does he show a knowledge of the problem in hand?			
c. Does he show a knowledge of related subjects?			
d. Does he show a knowledge of what is going on in his community, state, nation and the world?			
2. Skill in selection and organization of subject matter.			
a. Does he select significant and valuable portions of subject matter for discussion?			
b. Does he show a knowledge of the psychological method of organizing subject matter?			
c. Are relative portions of the text recognized and emphasized?			
d. Are materials outside the text used?			
e. Are exact references given?			
f. Are local conditions and situations utilized in teaching whenever possible?			
g. Is the reference material readily available?			
3. Skill in making the assignment.			
a. Does the assignment present a stimulating problem?			
b. Is the problem given a setting that is significant for pupils?			
c. Is the assignment more than a mere announcement of the number of pages in the text?			
d. Is the assignment developed with the class?			
e. Do pupils know what the assignment is?			
f. Is the assignment made to cover a unit of the subject matter?			
g. Are pupils led to accept responsibility for the accomplishment of the assignment?			
4. Skill in questioning.			
a. Do questions show they were systematically planned and spontaneously asked?			
b. Are they thought provoking or trivial?			
c. Do pupils ask questions?			
d. Is he facile in utilizing questions asked by pupils?			
e. Does he distribute his questions well among the members of the class?			
f. Does he ask the question first, then call on the pupil to answer?			
g. Does he avoid repeating answers given by pupils?			

	High	Av.	Low
h. Is the number of questions asked in keeping with good thinking on the part of the class?			
i. Are questions requiring summaries and organizations asked?			
5. Skill in organization and conduct of drills.			
a. Does he select points for permanent retention?			
b. Do pupils help select such points and know what they are?			
c. Does he review important points of previous lessons?			
d. Does he conduct periodic or topical reviews?			
e. Does he use available drill materials in science?			
f. Does he prepare drills for specific points?			
g. Does he realize that right practice makes perfect?			
6. Skill in explanation, illustration and demonstration.			
a. Are illustrations and demonstrations used to clarify general statements?			
b. Are blackboard sketches used?			
c. Is blackboard work neat and accurate?			
d. Are explanations stated simply and clearly?			
e. Do the demonstrations always demonstrate?			
f. Are motion pictures and projection lantern slides used when practicable?			
g. Are verbal illustrations used by pupils and by the teacher?			
h. Do the illustrations and demonstrations add force to the point rather than become central in themselves?			
7. Skill in securing class participation in recitations.			
a. Do all pupils take part in the discussions?			
b. Do pupils question each other and aid in the conduct of the recitation?			
c. Does the teacher dominate the recitation or do the pupils contribute in a large measure to its progress?			
d. Does the teacher make provision for pupil-activity in the recitation?			
(1) By special assignments?			
(2) By utilizing special observations and experiences of the pupils?			
e. Is the pupil participation significant or largely irrelevant?			
8. Knowledge of how children learn.			
a. Does he encourage self-activity on the part of his pupils?			
b. Do pupils make recitation of considerable length?			
c. Does he provide adequate motives?			

	High	Av.	Low
d. Does he make specific just what is good?			
e. Does he propose problems and topics of recognized value to pupils?			
f. Does he make provision for individual differences in ability to learn?			
g. Does he make provision for differences in the interests of pupils?			
h. Are the punishments and rewards meaningful in the pupil's world?			
9. Skill in directing study.			
a. Is some time spent in the study of the new assignment during the class hour?			
b. Are specific directions given for the study of each new type of material?			
c. Are difficulties anticipated and is there some explanation given in advance?			
d. Are pupils led to use books and reference materi als to the best advantage?			
e. Is he always on hand and ready to help during the study hour?			
10. Skill in organizing and conducting field and laboratory work.			
a. Is field or laboratory work done whenever it is educationally valuable?			
b. Is the laboratory or field work closely correlated with class work?			
c. Are laboratory or field results used in the class work?			
d. Do pupils show some independence in field or laboratory work?			
e. Is he skillful in contriving apparatus or in pointing out facts of interest in the field?			
11. Use of adequate tests.			
a. Does he use informal objective examinations?			
b. Is he skillful in the construction of such tests?			
c. Does he use the best standardized tests in science?			
d. Does he show a knowledge of the normal distribution of abilities?			
12. Skill in lesson planning.			
a. Does he have a well worked out plan for the lesson?			
b. Is the class hour conducted as planned?			
c. Does he differentiate between subject matter and method?			
d. Does he write points of correction or a short summary of results of the lesson for further reference, or for use with another class?			
13. Attention to language expression.			
a. Does he use good English?			
b. Do his pupils use good English?			

	High	Av.	Low
c. Do pupils express themselves adequately in reports and recitations?			
14. Skill in class management and discipline.			
a. Is the class so arranged as to encourage group participation?			
b. Does the class work proceed smoothly and without interruption?			
c. Is order maintained through co-operation rather than through coercion or suppression?			
d. Is routine, as passing materials, passing to blackboards, to laboratories, etc., systematically organized?			
e. Is the feeling of responsibility for class accomplishment secured?			
15. Skill in the use of mechanical stimulation.			
a. Does he use his voice to good advantage?			
b. Does his voice show cultivation?			
c. Does he make use of humor at times?			
d. Is he thoroughly human in his attitude toward pupils?			
e. Does he vary the classwork to avoid too much routine?			
16. Skill in creating attitudes, habits, etc.			
a. Is neatness and order developed in pupils?			
b. Is critical mindedness fostered in dealing with materials and apparatus?			
c. Is intellectual honesty demanded in reporting materials?			
d. Do pupils seem to enjoy doing their school work?			
e. Does he teach pupils to analyze problems for themselves?			

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DIVISIBILITY OF NUMBERS AND ALGEBRAIC DIVISION.

By M. O. Tripp,

Wittenberg College, Springfield, Ohio.

One of the topics which cause much trouble in the teaching of the first term's work in Algebra is division. Often this topic is presented in such an abstract manner that students lose interest in mathematics. They frequently feel that algebra is merely a juggling of symbols, rather than a study of the ideas behind these symbols.

As a means of vitalizing division certain principles in the divisibility of numbers may be studied. This offers an effective connecting link between the concrete arithmetic which the student has been considering in the grades and the more abstract work of generalized arithmetic, or ordinary algebra.

In order to test divisibility by 2 let us represent every possible integer in the form

$$10k+x,$$

where k is a suitably chosen positive number and x one of the digits 0, 1, 2, 3, ... , 9. Thus, in considering 437, we have $k = 43$ and $x = 7$.

By division we have

$$\frac{10k+x}{2} = 5k+\frac{x}{2}.$$

The first term on the right side of this equation is always an integer, since k is an integer. The second term on the right, $\frac{x}{2}$, will be an integer provided x is an even number, Hence the whole right side is an integer whenever x is an even number. It is evident that the left side is an integer when the right side is an integer. Hence any number is divisible by 2 when the right hand digit is even.

To test divisibility by 3 we consider integers having various numbers of digits. For example, any number of two digits can be expressed in the form

$$10y+x,$$

where x and y are digits, 0, 1, 2, 3, ... 9.

Dividing this expression by 3 we have

$$\frac{10y+x}{3} = 3y+\frac{y+x}{3}.$$

The first term on the right is always an integer. The second term on the right will be an integer provided $x+y$, or the sum of the two digits is divisible by 3. Hence the left side will be an integer when the sum of the two digits x and y is divisible by 3.

Next we take an integer composed of three digits, namely,

$$100x+10y+z,$$

where x, y, z are digits 0, 1, 2, 3, ..., 9.

Dividing by 3 we have

$$\frac{100x+10y+z}{3} = 33x+3y+\frac{x+y+z}{3}.$$

The sum of the first two terms on the right is an integer. Hence the whole right side will be an integer provided $(x+y+z)$ is divisible by 3, that is, any number of three digits is divisible by 3 provided the sum of the digits is divisible by 3.

It is evident that the process may be continued in the same way with integers of 4, 5, 6, ... digits.

To test divisibility by 4 we write any given number in the form

$$100k+10x+y,$$

where k is a suitably chosen integer, and x, y are digits. For the number 5678, $k = 56, x = 7, y = 8$. Division by 4 gives us the result,

$$\frac{100k+10x+y}{4} = 25k+\frac{10x+y}{4}.$$

The peculiar form of the remainder in this case needs especial explanation on the part of the teacher. The first term on the right is an integer. Hence the right side will be an integer provided the number $10x+y$, or the number formed from the last two digits, is divisible by 4.

Divisibility by 8 may be tested similarly by putting our given number in the form

$$1000k+100x+10y+z,$$

where k is a suitably chosen integer, and x, y, z are digits. Hence, just as in the preceding case, a number is divisible by 8 when the number formed from the last three digits is divisible by 8.

Continuing in this way it is evident that any number

$$10^nk+10^{n-1}x+10^{n-2}y+ \ . \ . \ . \ . \ .$$

is divisible by 2^n, provided

$$10^{n-1}x+10^{n-2}y+ \ . \ . \ . \ .$$

is divisible by 2^n, $(n = \text{positive integer})$.

Any number is divisible by 6 if 4 times the sum of the digits of higher order than the units' digit plus the units' digit is divisible by 6. For example, for a number of four digits

$$\frac{1000x+100y+10z+w}{6} = 166x+16y+z+\frac{4x+4y+4z+w}{6}.$$

This theorem is based upon the fact that

$$10^k \equiv 4 \text{ (mod. 6)},$$

if k = a positive integer greater than zero. Naturally the case of divisibility by 6 according to this scheme is more difficult, and should not in general be taken up by beginners in algebra.

It is well known that the rule concerning divisibility by 7 given in books on number theory is not a practical rule which students would use; for, in general, it is easier to test by actual division than to use the rule.

Consider the number of three digits

$$100x+10y+z,$$

which if we divide by 7 gives

$$\frac{100x+10y+z}{7} = 14x+y+\frac{2x+3y+z}{7}$$

In this case students should be taught to interpret the result, since they have, in all probability, never before met this test for divisibility by 7.

Divisibility by 9 follows the same line of procedure as divisibility by 3, and leads to the same result with regard to the combination of digits.

For the case of a divisor 13 we have

$$\frac{100x+10y+z}{13} = 7x+\frac{9x+10y+z}{13}.$$

Likewise for a number of four digits we have

$$\frac{1000w+100x+10y+z}{13} = 76w+7x+\frac{12w+9x+10y+z}{13} =$$

$$77w+7x+\frac{9x+10y+z-w}{13}.$$

Thus a number of four digits is divisible by 13 if 9 times the hundreds' digit plus the number formed from the tens' and units' digit minus the thousands' digit is divisible by 13. For example, 1794 is divisible by 13, since $63+94-1$ is divisible by 13.

As a last case let us test divisibility by 17.

$$\frac{1000w+100x+10y+z}{17}=59w+6x+\frac{10y+z-(2x+3w)}{17}.$$

Thus a number of four digits is divisible by 17 if the number composed of the last two digits on the right minus the sum of two times the hundreds' digit and three times the thousands' digit is divisible by 17.

Just as in the above the well known rule for divisibility by 11 may be easily obtained. In deriving this rule care must be taken to get the remainder in proper form.

The examples here given are sufficient to show various concrete applications of algebraic division to the problem of divisibility of numbers.

FROM THE SCRAPBOOK OF A TEACHER OF SCIENCE.

By Duane Roller,

Calif. Institute of Technology, Pasadena.

It is amusing to note the many things which college instructors and the writers of text books include in their lectures and manuals which they themselves would not be able to recollect between times. What a considerable and beneficent revolution would take place in teaching and writing if teacher and writer should confine himself, at least in addressing beginners or laymen, to telling only such facts as play so important a part in his own everyday thinking that he could recall them without looking them up.—*James Harvey Robinson, writer and historian, in "The Humanizing of Knowledge," 1923.*

There is a book which only eight men in Europe are capable of understanding; and the author is not one of that number. —*Bernard le Bovier Fontenelle, on presenting his "Essay on the Geometry of the Infinite" to the Regent of France.*

The story is told of the debutante who met the renowned astronomer, the lion of the evening, with an appreciative remark as to the wonders of astronomy, "And do you know I think the most wonderful thing is how we know the names of the stars." —*John Mills in "Within the Atom."*

On the heights it is warmer than people in the valleys suppose, especially in winter. The thinker recognizes the full import of this simile.—*Friedrich Wilhelm Nietzsche in "Maxims."*

> Lo, the poor Indian! whose untutor'd mind
> Sees God in clouds, or hears him in the wind;
> His soul proud Science never taught to stray
> Far as the solar walk or milky way.
> —*Alexander Pope, English poet, in "Essay on Man."*

A FEW HINTS FOR GIVING VARIETY TO ASSIGNMENTS AND RECITATIONS IN BIOLOGY.

By J. Edna Johnson,
New Haven High School, New Haven, Conn.

"Tell us" said the editor of this magazine in a recent issue, "how you do your stuff." It occurred to me when I read this that perhaps some of the methods of giving assignments and conducting recitations which I have collected from various sources and have used in my own classes might be of interest.

Educators are continually advising teachers to make their assignments definite; to break away from the old question and answer method of recitation; to make all students participate in the work of the class. As it is difficult to find explicit directions for doing these things I am offering a few suggestions which I have found helpful. Some of the devices presented in this paper were offered by other teachers, some adapted from Waples' "Problems in Classroom Method" and Douglass' "Modern High School Teaching," and a few are my own.

The Assignment.

"The most important quality of a good assignment" says Douglass is definiteness. To prove this he states that he asked members of a score or more of his classes to think back to their high school days and to recall what subjects they prepared most regularly and most completely. In every instance he found that mathematics and foreign languages ranked first and second with some other study a poor third. When those who designated mathematics and foreign languages were asked if these were the subjects they liked best, the majority indicated that the reason for their better preparation lay not in their preference for these subjects but in the definiteness of the work assigned them.

Oral assignments usually result in poor preparation and conflicting statements as to just what the assignment was. A written assignment that reads: "Take pages 25-29" usually means to the pupil to commit these pages to memory. This he attempts to do, giving the important facts and the unimportant details the same amount of attention. Following are a few suggestions for avoiding such difficulties:

The Assignment.

A. Vary the form of the assignment. Have different kinds of things to do either in the same assignment or in different days' assignments.

1. Give a list of questions based on the text for the student to look up.
2. Use some of the forms employed in the newer types of examinations. This is usually stimulating form of assignment.

For example: a. Match these words:

Wing	Head
Abdomen	Kidney tubules
Antennae	Spiracles
Excretion	Thorax

b. A whole assignment may be made into true and false statements to check with the text book. This insures careful reading of the assigned pages.

3. A list of topics may be given such as: The structure of a root, the function of roots, forms of roots.

4. Certain pages may be assigned and students asked to prepare 10 or 15 questions on these pages that they can answer themselves. The student may be asked to conduct the class using her questions. Others may contribute points which she has omitted.

5. An excellent form for part of an assignment is the best answer exercise. The following example was taken from Waples' "Problems in Classroom Method." The student is asked to check the statements he considers reasonable in the experiment on osmosis of egg in glass of water.

a. The rising of the liquid in the tube was caused by air pressure.

b. The liquid in the tube is the albumen of the egg.

c. The liquid is the water from the glass.

d. The liquid is a mixture of water and albumen.

e. The water of the glass passed through the membrane into the albumen. There was no reverse movement, etc.

B. Vary not only the form of the assignment but the way in which it is given. It is monotonous to say daily: "The assignment for tomorrow will be ...." Occasionally change to "Shall we study the eye tomorrow?" or "What do you think of beginning the study of animals with the grasshopper?" If possible, make it appear that the class has a part in it. Student participation makes the work seem less of a task.

The Recitation.

A. Recitation on advanced work.

1. The following device sometimes secures interest particularly in bright classes. Turn the recitation into an oral examination, modelled after that given candidates for the degree of Doctor of Philosophy in a university. Different candidates are prepared on different parts of the assignment and are questioned by the other members of the class or by a special group who fail or pass the applicant for the degree.

2. It is a change to write the advanced lesson on the board with blanks to fill in. Students usually begin to work on it as soon as they come into the room and appear to welcome it as a diversion. It is a method of getting a whole class working at once.

3. Special topics are an old device. The work is usually done willingly, however, because the student feels that he can give information not known by the other members of the class. The topics can be somewhat enlivened if they are illustrated by lantern slides, charts or diagrams. The class will pay better attention if the student has prepared a list of questions and put them on the board. The class is held responsible for these questions after the pupil has finished.

4. If the student or teacher reads from a book or magazine, an outline or list of questions on the board ensures the attention of the class.

5. Recitation on advanced work or review can be turned into an "Ask me another" contest, or if that is a little old, use the title given to a certain department in many newspapers: "Memory Teasers."

6. A different topic may be assigned to the various rows and one girl made chairman of each row. The duty of the chairman is to subdivide the topic and assign parts to different girls. When the recitation period arrives, the chairman of the first row arises, gives her topic, makes some introductory statements and says: "Sadie will now tell us about ...." When Sadie has finished the chairman introduces John who discusses another phase, etc.

7. A variation of the above is to assign a topic to each row. When the

class assembles, let each row choose a speaker to discuss their topic. After the speaker has finished, other members of his group correct or add to what he has said.

8. With very dull classes it is sometimes desirable to recite with textbooks open. They may be given time to fill in blanks in an exercise previously written on the board or to prepare topics assigned them.

B. The Recitation on Review Work:

1. Number every student in the class. Write the numbers on the board and have one student stand there with 30 or 40 written review questions. He reads a question, calls any number and crosses it off. The student whose number it is answers the question.

2. Write 20 or more questions on the board, and place one student at the board to check questions chosen. Call on a pupil to recite on any of the questions he chooses. When he has finished he calls on another pupil who likewise makes his choice from the questions left. This will keep students interested until the majority of the class has recited because as soon as the questions they have selected for themselves are taken they must be prepared with others.

3. It clarifies a subject if when it is about completed it is outlined and put on the board, the class reciting from the outline.

4. Make a detailed outline of a subject and put on the board with the topics and subtopics out of order. Have the class rewrite the outline in its proper order.

5. A modified spelling match is sometimes successful, questions being used instead of words. Instead of choosing sides and standing, and sitting down when failures are made, number every student, let the leaders choose sides, the numbers representing the students being placed in 2 groups on the board. As a student fails, his number is erased from the board. There is much less confusion than in the old way.

6. Biological Vocabulary: A stomate is: A breathing organ in a grasshopper; an enzyme used for digesting food; a breathing organ in a plant. Ovipositor is: Term applied to egg laying animal; the undeveloped seed; egg laying apparatus.

7. Sequence of Events: This may be applied to processes like fertilization in a plant, digestion and circulation in an animal, or the whole process of nutrition in an animal. The statements are rearranged by the pupils so that they come in their proper order. For instance, as applied to circulation: Blood flows through capillaries in all parts of the body. Blood flows from the left ventricle into the aorta. Blood enters right auricle by means of the superior and inferior vena cava. Etc.

SYNTHESIS OF SUGARS.

An approximation of the process whereby living plants produce sugar from water and carbon dioxid, using the energy of light to make the combination, has been accomplished in the laboratory of Prof. E. C. C. Baly of Liverpool University. Using the most elaborate precautions against contamination of either his materials or the glass vessels used in the experiments, the British scientist and his associates have repeatedly produced substances that pass all the chemical tests for sugars.

The first tests were made with the invisible ultra-violet light as the source of energy. In these experiments, finely powdered iron and aluminum compounds were introduced into the water. These took no part in the reaction, but acted as catalysts, or chemical go-betweens, furnishing a large spread of surface on which the chemical action could take place.

But in nature the formation of food substances by plants is carried on by the power of visible rather than invisible light. The experimenters therefore sought a closer artificial approach to natural conditions. Since leaves have colored substances in them, colored catalysts were sought for the sugar-formation going on in the glass tubes. For this purpose carbonates of cobalt and nickel, both of which are colored salts, were found useful. With these in the tubes exposed to visible light from electric lamps, the carbon dioxid and water produced the sugars quite as readily as they came into being with colorless catalysts under ultraviolet light.—*Science News-Letter*.

THE EFFECTIVE USE OF PRACTICAL EQUIPMENT IN A PHYSICS COURSE.*

BY ELLSWORTH S. OBOURN,

The John Burroughs School, St. Louis, Mo.

When the report of the Committee of Ten, submitted about 1892, crystallized high school physics into a diluted university course, it was nearly an educational felony to have about a physics laboratory very much material which might be characterized as practical. The teacher-centric idea of education predominated in physics and the pupil had little opportunity to handle equipment. Physics was thought to be one of the best disciplinary subjects in the curriculum and was pursued by many for the sheer value of training the reasoning powers.

About 1907 a movement began in this country which was most probably due to a direct reaction against the Report of the Committee of Ten. This movement seemed to be particularly characterized by a trend toward the practical in physics. Text books began to introduce more discussion material related to the application of physics and occasionally a teacher would bring into his class a practical piece to illustrate some law or principle. The major part of the textbooks however still retained the extreme theoretical treatment of most of the material and deemed it a descent to include much of applied science.

This movement, once started, has never been stemmed, and the last ten years have seen a development which is most remarkable in many ways. The pendulum has swung to the other extreme, and we find ourselves now in what might be termed the ultra-practical period. It was only a few years ago that a great many text book writers tried, each to out-do the other in giving to their books a name bespeaking the utilitarian. This, however, proved mostly a wolf in sheep's clothing, for about the only change from the older editions was an added chapter on the automobile or an adding here and there of a bit on the aeroplane, radio, or other recent advancement.

There is little doubt but that this movement has had a dominant effect upon the equipping of high school laboratories. This is especially true of the modern city high school where one may now always find, along with the more conventional pieces, a variety of practical equipment. It seems to me that this is

*Read before the Physics Club of St. Louis and Vicinity at the November, 1926, meeting.

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*Read before the Physics Club of St. Louis and Vicinity at the November, 1926, meeting.

one of the best evidences of the desire of the modern teacher to break away from the old disciplinary objective of physics teaching and to make it a vital functioning subject in the life of his pupils.

It is about the effective use of this practical equipment that I would like to speak briefly. A few years ago I chanced to be connected with a physics department of one of the large teacher-training universities of the country. In the laboratory of that department one could find practical pieces of most any type or variety. There were gas engines, steam engines, hydraulic rams, lift pumps, hot water heating systems, vacuum cleaners, electrical devices of all types and many others. To my surprise this material was seldom used and upon inquiring from the professor in charge as to its presence, he replied that the principal place of large, "life-size" pieces, as he called them, was for inspiration and atmosphere and that their value for other purposes was not great. In many cases today this same idea is prevalent, that the practical piece is good only for inspiration and atmosphere.

In some schools practical materials play a rather minor part in their use as merely illustrations of the application of certain principles or laws. They are merely pointed to, much as one would refer to a diagram or cut in the textbook, without any thought as to how they apply the principles or how they operate. In other places the practical piece finds a use as demonstration equipment for the teacher, and as such, it is probably assuming its most effective present use.

A casual examination of the most commonly used laboratory manuals in physics seems to reveal the fact that in very few instances do pupils have the opportunity to manipulate and study practical equipment or to think their physics into real life situations. Such an examination of three of the most commonly used manuals shows that less than 15% of the experiments require any equipment which might find its counterpart in the life experience of the child. A further examination gives evidence that authors are pretty generally agreed upon the possibilities of the use of practical equipment. One will always find the water motor, the block and tackle, the lifting jack, the gas stove, the electric heater, and a few others but they stop here. The question naturally arises, are these the only situations in which physics can find use in the life of the child? If so, we could better devote our energies to some other field and

remove it from the curriculum.

A few suggestions as to the possibilities of widening this very vital phase of physics teaching are here in order. These are a few. Others are doubtless possible and perhaps are already in use: The wheel and axle, the inclined plane, measuring water pressures, the differential pulley, the hydraulic lift, the coefficient of friction, the vacuum cleaner, the automobile tire, the air brake, the crow bar, the wheel-barrow, use of the lactometer, the piano, the arc light, the water meter, faucets, the gas meter, carburetors, auto speedometers, auto head lights, life preservers, lift pumps, hydraulic rams, the fireless cooker, the pressure cooker, the line transformer, the thermos bottle, the electric stove, the refrigerator, thermometers.

A great many of these pieces of equipment may be had at a very low cost from mail order houses or may be borrowed in many instances from local hardware stores. Many can be brought from home. The junk dealer will often have old lift pumps, auto parts, faucets, etc. A great many of them can be improvised by the ingenious teacher. Whatever the source, the end sought will more than justify the means.

A characteristic and common reason for the general lack of practical pieces in many new physics laboratories is that colleges do not require it for entrance, or that the college entrance course is too extensive to allow time for such a type of work. But a little reflection only is needed to see that neither of these is altogether sound. In the first place we can immediately say that the major objective of secondary education today is not preparation for college. Statistics show that out of 100 pupils who enter the Freshman class of high school about 10 enter college. It is evident that, regardless of requirements, our function is to prepare, as far as physics is concerned, for an efficient citizenship. Also it is not altogether a demonstrated fact that pupils are not as amply prepared for college by a course in physics enrichened by the use of practical equipment instead of the time worn pieces of the past.

One might justly ask at this point, To what extent does the physics subject matter as now taught function in the lives of the pupils who take it? We have some little evidence at hand to indicate that much of it is not functioning at all. This situation is not alone in the field of physics but in the past decade the accusation has been pretty generally brought against the entire field of secondary education. As a result we have gone

through a complete revision of high school mathematics and social science curriculums. There is at present a great need in the field of high school science for objective studies to reveal the things we should teach and then a revamping of our present practice to meet these needs.

If we grant that a great body of our present subject matter in physics is learned only for a short period and fails to function in the child's outside activities, we may inquire as to the why of the situation. Modern psychology has long looked upon the general transfer of training from one situation to another as unsound, and today recognizes that for learning in one situation to be transferable to another in a different context, the two must have fundamental elements in common. Is not our present practice of physics teaching just filled with cases in which we completely disregard these findings of modern psychology? In our teaching of the elements of the inclined plane, for example, we are teaching the child to think in terms of a near-frictionless car with as near an ideal situation as it is possible to create. Can the child make the transfer in such a situation as readily as if he is given a plank, a rope and a loaded keg or barrel to carry out his study? All the evidence of modern psychology would point to the contrary. Our greatest failure it seems to me comes right at this point, in that instead of confronting the child with real problems growing out of real life-sized material we are completely enshrouding him in artificial situations having very few, if any, elements in common with his after school life.

If we examine some of the ideas of modern educational thinkers as regards the problem it is not difficult to see that the proper use of practical equipment will carry us a long way toward the accomplishment of a worth while objective of functioning physics:

Bobbitt[1]—"Every aspect of the science is to be introduced, when possible, by full, direct and normal contacts with the concrete realities themselves; when not possible, then by the best practical substitutes.

"Contacts with the realities of science are to be of *normal living* type as fully as possible: using things; seeing them used; adjusting and caring for them; normal direct observation; explaining things to others; analyzing things for one's intellectual satisfaction, especially as problems arise."

[1]Bobbitt, How to "Make a Curriculum"—Houghton, Mifflin Co.

Morrison[2]—"The most that the school can do is to bring together appropriate and selected bodies of experience which themselves interpret and explain different aspects of the environment, and arrange such experiences in the form in which reflection can be stimulated and made most economical."

Twiss[3]—"Real knowledge of a law or principle—that is facility, or skill in using it—can be gained only by practice in dealing with problematic situations in which it is involved."

Dewey[4]—"More over by following, in connection with problems selected from the material of ordinary acquaintance, the methods by which scientific men have reached their perfected knowledge, he gains independent power to deal with material within his range, and avoids the mental confusion and intellectual distaste attendant upon studying matter whose meaning is only symbolic.'"

In summary of the above it is obvious that at present practical equipment is used for two purposes, one where it merely serves as illustrative material without much inquiry as to its operative principle, and the other where it is used as a demonstration piece by the instructor. While the latter use is somewhat effective it is a long way from the full realization of the possibilities.

If we are to go the full distance and make our physics teaching function in the lives of our pupils, we must, it seems to me, recognize two additional steps in the learning process as applied to physics. First, a step of Organization, and secondly, a step of Application. The first, in which the child is given an opportunity to organize his knowledge about a certain topic, and the second in which he is allowed to apply this organized knowledge in a specific life situation.

Too frequently our pupils leave a unit of instruction without a definite mastery of it due to poor organization. This, it seems to me, defeats the very end of teaching itself and therefore some form of organization should become as integral a part of the teaching process as the assignment, recitation or review. This may be accomplished in many ways, but a written outline of the unit, done without the aid of book or notes, has proved the most effective in the writer's classes.

This step of Organization leads quite naturally into a step of Application. It is here that practical materials may find

[2]Morrison, Henry C. "The Practice of Teaching in the Secondary School." The University of Chicago Press.
[3]Twiss—"Principles of Science Teaching"—Macmillan.
[4]Dewey—"Democracy and Education"—Macmillan.

their most effective use. When the pupil has fully mastered the subject matter of a topic and has organized it well in his own mind, he should then be led to think the law or principle into a concrete life situation through a carefully planned application exercise in which he manipulates, dissects and analyzes a life-sized device. It seems to me that unless we recognize these additional steps, that we are bringing our pupils up to a point where real learning may begin and leaving them stranded in a maze of doubt and confusion.

INSECT ZOO IN PARIS.

What might be called an insect zoo has just opened in Paris where the public is turning its attention from the lions and tigers in the menageries to see the new vivarium in the *Jardin des Plantes*. Here it has the extraordinary experience of watching insects in their natural environments, each group shown in an indoor glass cage fitted up to seem like home to the inhabitants.

This somewhat unique accomplishment has not been so easy as it might seem. The insects come from various climates and their requirements are naturally vastly different. Thus a complicated heating system is necessary to simulate the African desert in one cage and a coolish temperature in the next. Heat, humidity, and light have all formed tremendous problems solved by the ingenuity of Dr. Jeannel, director of the vivarium.

In some cases it has been necessary to fool insects for the benefit of the public. In their desire to establish the closest possible contact with objects about them, the scorpions, if left to their own devices, would completely disappear from sight by burying themselves and leave the public to look at a seemingly empty cage. However, they seem very well satisfied to hide beneath plates of transparent glass through which they can easily be seen.

A pair of giant phasmas have shown that hens are not the only ones whose reproduction is affected by electric light. For two months they failed to reproduce but the day an electric light was put in their cage they responded accordingly.

Several cages are devoted to exhibits of insect mimicry. There are the giant phasmas just mentioned which look like the green leaves they feed upon, and others which exactly resemble the straw colored branches to which they are clinging. The observer must watch closely for some movement to tell which is which.

The vivarium is for the purpose of exhibiting all cold blooded animals in their natural environments, but the insect exhibits are the most unusual part of the program.—*Science News-Letter*.

THE THREEFOLD OBJECTIVE OF DRILL IN ARITHMETIC.

BY G. W. MYERS,
The University of Chicago.

Purposes of School Arithmetic.

The three leading objectives of public school arithmetic are: (a) intelligent control of number and space procedures, (b) calculatory skill, and (c) problem-solving power. The corresponding teaching functions are: (a) securing rational insights, (b) conducting practice, or drill, and (c) organizing data and directing thinking. The functions overlap, are interrelated and all are essential.

Most of the literature for teacher-training and guidance, in journals as well as in texts, overstresses the importance of problem-solving ability as the one final criterion of mastery of arithmetic and correspondingly understresses the objective of rational insights into number relations and processes. Teaching practice generally tries to conform to this guidance, but in great measure fails because of its general impracticability. For these reasons it seems well to signal that however great may be the social utility of arithmetic for the average man or woman in the unprofessional walks of life, and it is very great, the social demand for arithmetic never for any but skilled professionals, rises to the complexity of need of skill with such "word" problems as are in most of the school arithmetics

Rational controls of number processes are however, for the "man in the street" continually in requisition, so much so indeed, that to make intelligent control of number and space procedures rather than problem-solving ability, the measure of the desired degree of mastery of public school arithmetic is much more closely in accord with the demands of life arithmetic than is the contrary practice. Tests sufficiently long in time and wide in range have been made in public school arithmetic to lead the open-minded teacher to discard the problem-solving fetish for the development of rational insights and intelligent understandings of the ever-recurring processes that control the quantitative thinking of life.

The foregoing statements are not to be construed to mean that we are advocating the taking of problem-solving ability from the category of objectives for arithmetic mastery. On the contrary the problem-solving objective is the highest of all. Our contention is that it is too high to be effective with most children. It can be attained only in modest degree by any but

the relatively few superior pupils. It is however an arithmetical asset so desirable in the work-a-day world that we must strive for it even in moderate degree for such as can attain it. Insight into and intelligent control of processes are so much more generally useful and attainable by the majority of pupils as to qualify ths objective for the first rank in a socially usable mastery of school arithmetic. We must however keep up the unremittent struggle for some appreciable measure of problem-solving power, but let us not forget that there can be high social mastery of arithmetic without any considerable degree of mastery of such problem-skill as the customary "word" problems of current texts represent. Excessive preoccupation with this type of problem-solving skill to the extent of making it the ruling objective cannot but continue to result in futility.

Aspects of Teaching Method.

Teaching methods necessarily vary according as the teacher seeks to impart ability, or skill, or power. For all these aspects of knowledge-control the aim of methodology is and has long been to select techniques that are capable of yielding objectively and reliably measurable outcomes. Some modest success has been attained in the methodology of abilities, rather high success has come in the domain of the development of skills, while very low success has come in the way of methods for developing power, the latter in the sense of control of ability-skill complexes. The result has been something of an exaggeration of teaching emphasis on the development of the skills of arithmetic. Teachers like to do what they can do well, and can prove that they have done well. We shall not however be able to use most effectively the refined techniques for skill development that have been devised and are available to the classroom practitioner, until we come to recognize that the *legitimate purposes of drill in arithmetic are varied* and that each variant purpose calls for its appropriate type of material. It is the prime intent of this paper to set forth these variant purposes and drill-types rather concretely and with sufficient fulness for practical purposes.

The Place of Drill.

Teaching texts and pedagogical writings have made the laws of habit formation sufficiently well known to teachers to justify the omission of specific citations of them here. Teachers *know* much better than they *do* in regard to the uses of drill in teaching. We purpose here to discuss drill from the standpoint of its specific and differentiated types as demanded by its variant

uses in the classroom.

The slogan "teach by drill" that was so popular a few years since, is already obsolescent and bids fair soon to become happily obsolete, as the drill-master type of teacher passes and the "soldiering" reaction of the learner comes to be more fully recognized as ineffectual learning response.

The normal activities, each of which in its turn should receive its appropriate teaching emphasis, in really teaching an arithmetical process or topic, are the following:

1. Motivate the topic.
2. Develop the concepts.
3. Assimilate the ideas.
4. Practice for skill.
5. Apply the new skill.
6. Problem tactics and strategy.
7. Consolidate new with old skills.
8. Keep recalling old skills to hold them.

The teaching procedure which we should call practice, but which is commonly called drill, is somewhat needed in step 2 of the foregoing list of activities and is the main reliance in the classroom for steps 3, 4, 7 and 8. Steps 3 and 4 are purely habituation matters and steps 7 and 8 are largely, if not mainly, habituation activities, as actually administered in teaching. Certain teachers claim to be able to accomplish the function of holding already acquired skills through other means than suitably built drills, but because of the difficulties involved in them, they are not much employed nor are they likely to be widely used. The main reliance for maintaining old skills must be suitably built drills, for such drills have been proved to be highly effective and relatively easily administrable in the hands of others than those who build them.

For the third step we need drill for stabilizing imperfectly mastered skills, or what we prefer to call "drill for assimilation." For the fourth step we need the two types, "drill to build skills" and "drill to maintain skills." A type of drill therefore which is a composite of the two types is best suited to this purpose. For steps 7 and 8 we need "drill to maintain skills." A few descriptive remarks on the main features of the several types of drill will here be in point.

Drill for Assimilation.

By this type of drill we mean enough practice with a new skill merely to stabilize it—to steady it sufficiently to make it rather readily available to early recall. Assimilation units are only outstanding subunits of the developmental units of arithmetical topics and processes. Good teaching is not content with merely motivating new ideas, and making them clear and vivid. If the

ideas are to remain in the learner's mind long enough after first exposure to be available without heavy reteaching the next time they are taken up, they must be gotten well over the threshold of consciousness—they must be anchored with some security to what is already in the mind. The new element must not only be seen clearly, it must be well understood and be manageable by the learner with a degree of ease. After the teacher has operated the new technique being taught, first before the pupil, then with the learner participating with the teacher and doing all he can himself to operate it, the state is reached when the pupil must operate it alone. This he must do repeatedly through appropriately constructed drill exercises. The exercises must all employ the new skill exclusively, admitting such variations only as are variant forms of the same essential skill. The law, "repetition with attention, allowing no exceptions," must here be observed. The exercises repeated must be focalized on the single skill being practiced, and its variant but not *exceptional* phases. The principle to guide here would seem to be:

"The exercises in drill for assimilation should be centered on a single skill, furnishing repetitions of the precise skill being assimilated."

After the development and assimilation stages have been completed, but not before, drill for habituation in those topics and processes that are to become the "ready-cash" elements of it, should be taken up. This aspect of drill is of two types which in the order of their being brought into service in teaching are "drill for skill-building" and "drill for skill-holding."

Drill for Skill-Building.

All competent teachers of the basic mathematical disciplines, especially of arithmetic, agree on establishing and developing skill as a main office of drill. Most are also in agreement on the general character of the material that should constitute such drill. The object of this type of drill is to reduce an already well-learned skill to automatic control. Speed and correctness are the goals. Only fundamental things need be subjected to this degree of control, but the fundamentals must not only be known, and well-known, but because of their frequent recurrence, they must be easily and unequivocally available for useful recall. The mastery must rise to the stage of reflex control. Relatively few things of algebra and geometry require such a degree of mastery, but many things of arithmetic must become well-built skills.

The guiding law for drill for skill-building is: *"Repetitions with*

attention, in close succession, allowing no exceptions." The requisite pupil experiences will come through exercises all concentrated upon a single skill, and its close variants. The repetitive practices must be "bunched" on the particular skill. Intervals for reflection must be reduced more and more narrowly until finally, only immediate reaction-time is allowed. The only variation allowable in the group of exercises employed, is such as the variant uses of the particular skill in hand demands. Admixture of the new skill with other older skills should be excluded from the exercises until the desired degree of facility in the new skill is attained. The exercises should be scientifically graded to the end that slow and backward pupils may make some appreciable progress. Otherwise, such pupils will become discouraged and be "bluffed" at the outset.

The general characteristics for the exercises for properly planned drills for skill-building may be stated:

"Scientifically graded, homogeneous exercises, focussed on a single skill and numerous enough to reach the attention-span approaching fatigue for the upper quartile of the class."

Drill for Skill-holding.

The vexing problem of maintaining already acquired skills in arithmetic while subsequent skills are being acquired is a matter on which competent pedagogical opinion is divided. The question is: Shall the old skills be maintained through distributive drills, through problem-units or perhaps, through a combination of both?

The viewpoint here taken is that it is safer, more economical and more readily administrable and supervisable to maintain the old skills chiefly through scientifically constructed drills, each of which shall contain a sampling of verbal problem units, placed at short and roughly regular intervals throughout the work of the school year, than it is to make problem work the reliance. A more detailed statement as to the nature of the constituent material of drills for skill-holding will be given below.

Some teachers advocate attempting to hold the old skills through the persistent use of suitably constructed problem lists, to avoid the too popular teaching device of drill such as most texts furnish in which quantity is the controlling consideration and mere undifferentiated bulk experience is all that is sought for the pupil. It is of course notorious that drills in which mere exaggeration of bulk characterizes the constituent material,

are highly ineffective as skill-holders. But objective findings of the experts have shown not only that such "bulk" drill does not hold the old skills of arithmetic, but also that the recourse to problem reliance is likewise ineffective. We need to remind ourselves that it is the *quality* rather than the *quantity* of the drill that determines its teaching and holding efficiency.

The plan of relying upon problem experiences has the merit of forcing increased emphasis upon the problem aspect of arithmetic, an aspect which is usually understressed. It also keeps the skills employed in close association with problem uses and situations, which has the virtue of making the skills more highly usable than are dissociated skills. But the fact remains that whatever merits this problem plan for skill-holding may have, it does not have the merit of holding the old skills. The skills of arithmetic still drop off during the 7th, 8th and 9th grades, whether the pupil is under a junior high school program or under the traditional eight-four or seven-four program. The threefold burden of practice, problem analysis and problem interpretation is too heavy and too complex for teaching situations to bear. Some one of these burdens will be slighted or dropped and classroom experience proves it to be generally the burden of practice for skill-holding that slips away.

We are however insisting more and more nowadays on truth to reality in problem situations, both as to backgrounds and as to the forms of the actual numbers involved in the problems. A purported problem must be a real problem, rather than real drill. To insert those numbers into the problems which will allocate the pupil repetitions upon the precise combinations that are most in need of them, usually distorts the problem and often destroys the real problem character of the situation. Furthermore, number combinations imbedded in verbal problems are much more difficult for learners than are the combinations when they appear as isolated exercises. The practice reaction is retarded by the twofold burden of an interpretation and analysis of a situation. Facile reactions, characteristics of good practice material, cannot be had under the conditions.

For the problem's sake the reaction must be deliberate, thoughtful; but for the practice in ready recall the reaction should be prompt, reflex. The two response-types are antagonistic. The outcome must be uneconomical, not to say wasteful. The repetitions are too slow for practice values and too speedy for problem values.

The real pedagogical issue then is to find some means, after a skill has been mastered and the class has moved on to topics involving new skills, of preventing the slipping away through too long disuse of the old skills. Rapid forgetting is the inevitable result, unless some way of combatting the forgetting is persistently and consistently pursued. The best way to prevent the lapsing of the old skills is to fight the forgetting week by week by spending a little time on mixed distributive drills, each drill embodying a considerable number of the fundamentals that have been previously learned. In addition to this practice in ready oblique recall, this type of distributive practice has high value from its tendency to *solidify* or *unify* numerous skills that have been mastered separately into a *total general skill.* The character of the exercises and problems constituting these drills differs very materially from that constituting drills for skill-building.

In the first place, the exercises and problems of the skill-holding drills must be widely distributed over many of the antecedent fundamental things of arithmetic. The sort of recall they must seek to exercise is "oblique recall," that is recall of a former skill when several different skills are on the threshold of consciousness. This is the sort of recall demanded by the problem situations of real life. As contrasted to the type of material for drills to build skills, skill-holding drills must be *distributive* over several processes, rather than concentrated on one process. They must also be distributive as to the learner's experience by being given to him frequently and at approximately regular periods not widely separated in time. The forgetting must not be allowed long to accumulate without systematic recalls of the fading old skills.

The skill-holding drills must also be scrupulously graded and provided with suitable scientific standards for measuring both the learner's status and his progress in tightening his hold on the old skills. For ease of administration it is essential that the scoring of his work shall be done by the learner himself. In this sense the drills should be self-testing, with provisions for self-help on the points in which the standards reveal the learner to be in need of practice. They must possess the property of focalizing learning and instructional effort on the precise things on which each individual learner needs remedial work. This makes such drills of high value as instruments for individualizing instruction and for focalizing remedial treatments.

To make the experiences of the learner in these drills as true as possible to those of the situations of real life the drills should

include problem situations as well as mechanical exercises. The time allotments of the standards must therefore be more generous than in the skill-building drills.

The distributive feature of the material of the drills must be actually calculated with sufficient closeness to make sure that the frequencies of occurrence of the old fundamentals and essentials shall be proportioned to their difficulty of retention and recall. The frequencies of the more recalcitrant skills in the learner's experience must be as great as, or greater than those of the more easily retained skills. This prorating of frequencies and pupil effort must be based not on guesses, however shrewd, but on actual findings from a sufficiently large number and varied range of pupil-reactions.

To gather into a sentence the distinguishing traits of properly organized drills for skill-holding, we may say:—

"Scientifically chosen and scrupulously graded exercises and problems, with calculated and apportioned distribution over several skills, both formal and applied, carefully standardized with generous time allotments, and adapted to focalizing the re-study and re-learning efforts of each individual learner upon his specific needs."

Because of their definiteness and their revealing character, such drill exercises become strong motivating agencies to pupil-endeavor, and reliable self-measuring devices for pupil-progress from week to week. They set reasonable goals for mastery at the successive levels of maturity, give reasonable standards for appraising one's approach to these goals, signify what must be done to make approach closer, all at a time when the temper of the learner favors "a bit of a spurt" to improve his record, since the revealed short-comings have not been allowed to accumulate to overwhelmingly large proportions before doing something about them. All this is quite in line with recent pedagogical precepts, some pertinent samples of which are the following:

1. The motivating effect of standardized drills depends upon one of the most powerful incentives to learning, viz.: *the awareness of success or failure at the moment of learning.*

2. A leading advantage of a well-graded drill is in furnishing the pupil an opportunity to work along through the drill until he reaches the limit of his ability.

3. To make school learning useful teach together the skills and abilities which life presents together.

4. A small amount of drill given frequently, is more effective for learning than is a large amount given infrequently.

5. The surest way to prevent forgetting is to fight it week by week, by spending a little time on mixed essentials, containing examples and problems involving the previously acquired skills.

6. The only remedial work worth doing is what is properly focalized on the precise skills and knowledges that have been shown to need it.

In conclusion then we may say that there are three distinctive and outstanding uses of drill in learning arithmetic, as indeed in mastering any other mathematical branch, each use requiring its own peculiar type of material, viz.:

I.—Drill for assimilation which is an organic part of development units, which seeks to stabilize first mastery for relatively short periods.

II.—Drill for skill-building, which aims at ready automatic responses.

III.—Drill for skill-holding, which seeks by periodic recall and restudy to make retention permanent, through longer periods.

The professional arithmetic teacher will recognize these distinctive functions of drill work and judge and choose his or her material wisely in view of the particular class of service needed. The day of blind, bulk, mass drill is passing, if not past. Properly organized textual drill material that recognizes the foregoing distinctive functions, may be of high service in the classroom. It would seem as unprofessional for the arithmetic teacher of today to give the old-time allopathic amounts of loosely bunched, coarsely judged drill material at long intervals, as for the modern physician to employ the leech, blood-letting and calamus root for all and sundry ills of his bailiwick.

The modern teaching tocsin is not "drill for teaching" but "drill for assimilation, for skill-building and skill-holding." With such a slogan translated into consistent practice, even the drill-master may be admitted with good standing into the modern pedagogical pageant.

NEW RELIGION NEEDED.

A new religion based upon the simple facts of life, teaching that life is immortal through the germ plasm, and urging youth to take the best sex partner in order to perpetuate and create a better race was demanded by Dr. Aldred Scott Warthin, director of the pathological laboratory of the University of Michigan. Youth today in the colleges and elsewhere is abandoning the old religious faiths based on superstition and a new religion based on science, teaching there is no forgiveness of sin, is needed to promote the evolution of the race in Dr. Warthin's opinion. —*Science News-Letter.*

THE TEACHING OF GENERAL SCIENCE.

By E. H. Sanguinet.

Development of General Science as a School Subject.

General science as an important school subject dates back to 1912[1] although books on general science have been published from time to time for the last one hundred and fifty years. The causes of the introduction of this subject into the curriculum are not exactly clear, but some plausible reasons are presented here. The immense increase in enrollment and the heterogeneous character of this new school population brought about a change in the principles of secondary education. Elimination studies revealed that a large number of students left school in the first and second years of high school without receiving training in the understanding of common environmental phenomena. Furthermore the practical nature of the study strongly appealed to both parents and students. As the various high school sciences were organized previous to 1910, pupils rarely came in contact with more than one or two sciences and a need for a broad and unifying science course was felt.

Organization of Courses of Study and Textbooks.

The introduction of general science into the curriculum was attended by much confusion as to the content of the subject. The first courses and textbooks contained a miscellaneous collection of materials drawn from the older sciences. One could almost predict by examining the content of the earlier textbooks whether the author was a professor of physics, biology, home economics, etc., by the amount of space given to particular topics. By 1918 when the subject was firmly established, books began to appear in which the materials of instruction were selected on the basis of the environment of the pupils without reference to the organization of the other sciences. A recent investigation[2] shows that there exists at the present time considerable agreement as to the content and organization of textbooks in general science. The teaching of general science has also improved much in the past few years. Before discussing learning and teaching it is desirable to state the concepts upon which the consideration of these topics will be based.

[1]Frank, J. O., "How to Teach General Science." Philadelphia: Blakiston's Son & Co. 1926.
[2]Weckel, Ada L. "Are Any Principles of Organization of General Science Evidenced by the Present Textbooks in the Subject." School Science and Mathematics, 22:44-51, January, 1922.

Learning and Teaching.

Although psychologists differ as to exactly how learning takes place, it is now generally conceded that one learns only through self-activity[3]. Therefore, it is the function of the teacher to give stimulation and direction in order that student self-activity may function in the most efficient and economical manner. Proper motivation and direction necessitates the establishment of valid goals or objectives toward which self-activity may be guided.

Objectives.

Objectives are usually considered as being of two types. The first type is called "ultimate objectives," "adult objectives," or "behavior objectives," and are expressed either in terms of socially accepted activities of adult life[4] or in such general terms as "ethical character"[5] or "social efficiency,"[6] which merely describe the quality of completed education or the general character of future desired conduct. The second type of objectives are called "immediate objectives" or "specific objectives" and are expressed in terms of "abilities," that is, "the ability to perform ————," "the ability to understand————," the ability to appreciate————." For the present purpose we are concerned only with the latter type of objectives which function as a guide to classroom teachers.

Immediate Objectives for General Science.

Courses of study[7] and textbooks[8] in general science are organized under such topical headings as "mechanical energy," "air and its properties," "sanitation—causes of disease," "the weather," etc. These units bear little or no direct relation to one another and this makes it preferable to state the immediate objectives for each unit[9] rather than for the course as a whole. This plan makes it easier for the teacher to focus his attention on the objectives immediately under consideration and facilitates

[3]Monroe, Walter S. "Directing Learning in the High School." Garden City, New York: Doubleday, Page & Co. 1927. p 1-4.
[4]Bobbitt, Franklin. "How to Make a Curriculum." Boston: Houghton, Mifflin Company, 1924. p. 8-9.
[5]"Report on Cardinal Principles of Secondary Education." United States Bureau of Education Bulletin, No. 35. Washington, 1918. 32 p.
[6]Spencer, Herbert. "Education." New York: A. L. Burt Company, 1918.
[7]Committee Reports. "Science for Grades 7, 8, and 9." Curriculum Bulletin, No. 14. St. Louis; Board of Education, 1926. 111 p.
[8]Snyder, W. H. Everyday Science. Boston: Allyn & Bacon, 1918.
[9]"General Science Syllabus. Courses of Study in Junior and Senior High Schools." Mineographed Bulletin, No. 4. Committee of Three of the Missouri State Teachers Association. P. 4.

keeping the immediate objectives and learning exercises in harmony with the ultimate objectives. Another device for clarifying the teacher's thinking in selecting and devising learning exercises[10] is the classification of the unit objectives.

Classification of Immediate Objectives.

Immediate objectives are outcomes of teaching and therefore may be classified under the types of learning involved in obtaining these controls of conduct. The classifications given by Bagley[11] and Monroe[12] are probably the best arrangements available. Monroe defines these *types of learning* as follows:

"1. *Specific Habits: Motor Skills and Fixed Associations.*

Under this head we place all outcomes of the learning process which function as automatic or largely mechanical controls of conduct. Names, dates, events, and other facts which have been memorized, belong to this class. In addition there are many habits which provide automatic motor responses. Examples of these are found in handwriting, the speaking of a foreign language, athletics, music, typewriting, and so forth. Specific habits provide ready-made responses to familiar situations.

"2. *Knowledge; Adaptive Controls af Conduct.*

Under the head of knowledge we group those controls of conduct (abilities) that function in overcoming difficulties presented by new situations. We commonly refer to them as ideas, concepts, meanings, principles, and laws. The distinction between specific habits and knowledge is primarily on the basis of the type of situation for which a response is provided. If the situation is familiar and the person possesses a ready-made response, the control of conduct is called a specific habit. If the situation is new, that is if it presents a problem to be solved and a response is manufactured by reflective thinking, knowledge is the name given to the controls of conduct that function.

"3. *General Patterns of Conduct.*

An ideal may be thought of as a general pattern to which conduct will conform in a variety of situations. Ideals have been described as "master ideas." In addition to the intellec-

[10]A learning exercise is any request made by the teacher to secure self-activity on part of the student.

[11]Bagley, W. C. "Educational Values." New York: The Macmillan Company, 1911. Chapters 2, 3, 4, and 5.

[12]Monroe, Walter S. "Teachers' Objectives." Bureau of Education Research Circular, No. 45. Urbana: University of Illinois, June, 1926. p 4-6.

tual element, the idea, there is an emotional element which adds power in controlling conduct. Neatness, honesty, patriotism, loyalty, altruism, and accuracy are names for certain common ideals.

Attitudes represent a number of less tangible but very important controls of conduct which furnish general patterns of conduct of "mind sets."

A similar kind of controls of conduct is designated as 'interests,' or 'tastes.'"

The example below illustrates the statement of unit objectives arranged under the three headings described above:

UNIT—"WATER AND ITS USES.

Unit Objectives.

A. *Knowledge:*

1. The ability to understand the importance of pure water and the problems of a city in supplying the inhabitants with water.
2. The ability to understand the methods of testing water for purity and precautionary methods to be used to insure pure water.
3. The ability to understand factors which affect the cost of water supply.
4. The ability to understand methods of getting water to the consumer.

B. *Specific habits; motor skills and fixed associations.*

1. The ability to read the water meter.
2. The ability to use the usual mechanical equipment of the household for the control of water.
3. The ability to direct others in the repairing of pumps, faucets, and plumbing.
4. The ability to cut off the water supply.
5. The ability to prevent the polution of drinking water.
6. The ability to purify water for drinking purposes when necessary.

C. *General patterns of conduct.*

1. An intelligent interest in the conservation of sources of pure water.
2. An intelligent interest in the maintenance of pure water supply.
3. An ideal of drinking only water from sanitary containers.

Determination of Immediate Objectives.

Formulating immediate objectives involves determining the abilities necessary to insure the proper functioning of the adult or behavior objectives. Two major theses have been presented as to the method of determining the adult objectives. The first contends that a list of the activities of adults should be compiled and analyzed, whereas the second insists that the interests and desires of pupils should be the basis. The Committee on Curriculum Making[13] recommends that both theories be used. It is rather difficult to make a detailed analysis of all man's environment and consequently most of the investigations have consisted of analyses of the interests and desires of children. Two recent investigations of this type[14, 15] apparently have produced good results. The study by Watkins also includes an analysis of the textbooks in the field of general science. The next step is to determine the learning exercises which will engender the abilities necessary for the proper functioning of the activities described in the adult objectives.

Learning Exercises.

Learning exercises are requests by the teacher which are designed to result in student activity. They should be explicit and worded in precise language. A learning exercise may result in comparatively simple activity on part of the student or in a series of more or less complex activities. In the beginning of the course the exercises should be of the more or less simple type and the directions should be specific. The more difficult activities should be delayed until late in the course and the accompanying directions should be less specific. In order to secure variety in exercises it is well to analyze the various types. A classification which is very helpful has been devised by W. S. Monroe[16] and lists the following types:

1. Direct or perceptual experiencing.
2. Vicarious experiencing.
3. Generalizing experiencing.
4. Comprehending the products of thought.

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[13]Twenty-sixth Yearbook of the National Society for the Study of Education. Part 2. Bloomington, Illinois: Public School Publishing Company, 1926. p. 11-28.

[14]Watkins, Ralph Knupp. "The technique and value of project teaching in general science." Columbia, Mo.: Missouri Store Company, 1923. 98 p. (Doctor's Thesis).

[15]Pollock, C. A. "Children's interests as a basis of what to teach in general science." Ohio State University Educational Research Bulletin, V. 3, No. 1., January, 1924.

[16]Monroe, Walter S. Directing Learning in the High School. Graden City, N. Y.: Doubleday, Page & Company, 1927. P. 30-39.

5. Using one's knowledge in manufacturing a response to a new situation.
6. Tracing the thinking of another person.
7. Expressing one's ideas.
8. Prolonging, repeating and intensifying one's experience.
9. Feeling or immotional activity.

The special nature of the materials of instruction in general science may justify the addition of

10. Construction activities.
11. Dissection activities.
12. Directing the actions or learning of another.
13. Collecting activities.
14. Identification activities.

It will be found that in both the original list and the proposed additions overlapping will occur and in such cases it is necessary to classify a learning exercise according to the dominant type. The function of such a classification is to avoid over-working any particular type of exercise and to insure that all types of desired controls will be engendered.

An examination of textbooks and courses of study in general science will reveal that the majority of the exercises will call for outcomes of knowledge or fixed associations. Relatively few motor skills are required in this subject. Drill exercises will therefore be in the minority. The wide range of topics covered and the nature of these topics make it comparatively easy to select varied types of exercises.

Assignment of Learning Exercises.

Junior high school students are preeminently at an actively inquiring and doing period of life. The interests of these students change frequently and are not focused for a long period of time on the same desire. These facts should be taken into consideration in assigning learning exercises. This is not interpreted to mean that students should be allowed to change exercises at will and that no attempt should be made to train them to stay with an exercise until it is completed in the proper manner. Wide variations in ability exist in the junior high school and lower senior high school grades as the elimination factor has not functioned as completely as in the upper high school grades. Different home conditions, different native mental and physical capacities, etc. result in wide ranges of abilities to achieve. Learning exercises must therefore be assigned which are adapted to these individual differences.

Adapting Learning Exercises to Individual Differences.

Sex differences[17] seem more pronounced in sciences than in the strictly academic subjects. All other factors being equal the exercises assigned to girls should pertain to household surroundings. A principle regarding the heating power of electricity probably would be engendered with less difficulty if applied to the curling iron or the electric stove.

The brighter students should be assigned a larger number of exercises calling for "generalizing experience," "using one's knowledge in manufacturing a response to a new situation," "expressing one's thoughts," whereas the slowest type would probably do well to master exercises in "direct or perceptual experiencing" with a minimum of the types of "tracing the thinking of another person," or "comprehending the product of thought." This does not mean that the types mentioned are the only ones to be used.

Exercises should not be too easy nor too hard but should challenge the abilities of students.

Motivating Learning Exercises.

If a student desires to do, to achieve, to appreciate, or to possess whatever is requested in a learning exercise, it may be said that the exercise is motivated. Motivation exists in all degrees from an almost passive attitude to the most aggressive and persistent attitude. There are many ways and means of securing motivation. To devise and properly execute these methods of stimulation is a very important task of the teacher.

Spontaneous Motivation.

Often it is only necessary for the teacher to call attention to a problem, to describe an interesting experiment, or to mention some event in order to secure immediate stimulation for a learning exercise. The spontaneous interest of students is much easier to obtain in general science than in most school subjects because it deals with the environment of the students and consists for most part of problems or projects with which they are somewhat familiar and in which they are already actively interested. Three of the brightest students in a science class requested the privilege of designing and building a steam engine during the laboratory period. They talked over their project with a stationary engineer on a hoisting engine and with the engineer on a branch railroad. Drawings were made and the engine was constructed

[17]Herriott, M. E. "Life activities and the physics curriculum." SCHOOL SCIENCE AND MATHEMATICS, 24:631-34, June, 1924.

of some No. 9, galvanized wire, a shaving soap can, a wheel off of a Christmas toy and a small amount of babbitt metal. These boys worked in the laboratory every day after school and several times had to be sent home. The boys in a manual training class in an adjoining room passed the science laboratory door in going to the finishing room. The sight of the engine project was too much for these boys to pass up and it was difficult to keep them moving by the door. The teacher in woodwork was forced to put a stop to unnecessary trips to the finishing room and the attendant stops while passing the science laboratory. In two weeks eight or ten steam engines had been constructed outside of school and practically all were improvements upon the original model.

A bird chart posted on the bulletin-board resulted in the voluntary organization of a bird club which met on Saturday mornings. Many other similar examples can be cited of almost spontaneous interest in general science work.

Motivation Through Interesting Reports.

In the writer's experience students have shown enthusiasm for doing exercises after a report had been made by a member of the class who had considerable experience with similar exercises. A son of a Professor of Biology who had gone on many field trips with his father gave a very interesting report of how he had made a collection of many species of wild flowers and exhibited his collection. The exercises calling for the identification and collection of harmful weeds and of local rocks and minerals needed little further stimulation on the part of the teacher.

Motivation by Means of Bulletin Board.

A teacher may stimulate student activities through the use of the bulletin board. Clippings of newspaper and magazine articles and interesting photographs pertaining to general science topics may be posted upon the bulletin board. The board should be located in such a manner that students have easy access to it. Groups of students will often collect to observe and read the material posted. Questions and suggestions for learning exercises will frequently result from well selected material.

Motivation by Means of Community Problems.

Good results in motivating activities may also be secured through reading aloud by the teacher or a student of articles from local newspapers which set forth some local problem such as community water supply or purification, epidemics due to poor sanitation, which touch intimately the lives of the pupils. An

article regarding a contemplated advance in the price of illuminating gas was used in one instance to motivate such activities as "to be able to read the gas meter," "development of an appreciation of conserving the gas supply," "an understanding of the properties of gas," and "a knowledge of the commercial processes of making gas."

Motivation by Means of Observing Use of Knowledge.

A few doors from the school building a neighbor had a very attractive front yard with different flowers blooming at all times. Students were asked "Name the flowers that are blooming in Mrs. X's garden this month," "Which flowers will be in bloom next month?" After several similar exercises students were led to see the practical advantage of possessing such knowledge as would be gained from learning activities growing out of exercises as "Which flowers bloom early in spring?" "Should these flowers be planted in a shady or sunny place?" "Do they grow from slips, seeds or bulbs?" and "Plan a garden in which flowers will be blooming all season."

Motivation by Means of Choice of Exercises.

Students' interests often become active when they are allowed to exercise their preference and choose from a number of learning exercises. This implies that the teacher must design a number of learning exercises which cause the student to develop the same control of conduct.

Motivation by Means of a Seasonable Sequence of Topics.

Most of the exercises in general science should be of a concrete nature as early adolescent children do not have the mental capacity or the necessary fundamental experiences to do a large amount of abstract thinking. In order to make particular types of learning activities more concrete and to stimulate students to perform these activities, it is frequently of advantage to follow a seasonable sequence. A study of things and events is often more intensive if they can be observed and examined.

Another phase of the same concept is represented by the motivation secured by visits to museums, field trips, and by motion pictures.

Motivation by Means of Outside of School Interests.

Strong interests in out of school events may be used by transferring this enthusiasm to classroom topics. A circus parade had just passed down the street on which the school was located and school had been dismissed for the period so that the students could view the parade. The teacher of the general science section

immediately following the parade realized that the students would be preoccupied and that the *mind set* must be changed before efficient and appropriate learning could take place. At that particular time the unit on hygiene and health was being studied. The teacher approached the subject by asking the class which things they liked best about the circus parade. After a discussion, a vote showed that the acrobats and the animals were the points of highest interest. The teacher followed up with the questions, "What do they feed the elephants?" "How much are they fed?" and "How often are they fed?" After these questions were answered for the elephants, they were repeated for the lions and tigers. The questions which served as a point of departure for real science work were: "Why do the elephants eat hay and the lions and tigers eat meat?" "How do they differ from human beings in physical equipment for masticating and digesting their food?" The succeeding lessons connected the physical condition and the feats performed by the acrobats with the exercise and health habits of the average man. In this way the powerful stimuli caused by the circus parade were used to good advantage in stimulating proper and profitable exercises.

Students frequently will furnish their own stimulation if the teacher is wide awake and will make use of the students' interests. The questions of students furnish good leads. Another source which will furnish excellent points of departure for exercises is the discussions and disagreements between students in the school yard and halls. A boy in the schoolyard made the remark that his father said a man who lived on Mars could jump fifty feet. He was promptly told by another boy that his "old man" did not know anything and that it was impossible for any man anywhere to jump even thirty feet. The argument attracted a crowd and a general discussion followed at white heat. Here was a fine chance for a teacher of general science to design many profitable exercises in astronomy.

Motivation Through Use of Instinctive Tendencies.

Adolescent students wish to "do things," they gain much satisfaction from handling and examining objects or events, from constructing or dissecting mechanical things. There seems to be a strong natural urge to know how a machine works, what is inside of it, and what makes it run. These natural tendencies may be used to great advantage in construction activities, dissection activities and collection activities.

The "gregarious or gang instinct" may be used to motivate

group projects, committee problems, and socialized recitations.

Demonstrations often motivate learning exercises through an appeal to curiosity. One experiment which gives good results consists of filling a small bottle with water colored by litmus, then inserting a glass tube which has been drawn to a fine jet into the stopper. A flask filled with ammonia gas is inverted over the bottle containing the litmus colored water and the jet inserted through the cork in the flask. Due to the absorption of the gas the pressure is changed and a small fountain will spray from the jet. A bombardment of questions usually follows this demonstration. Learning exercises regarding the absorption of gases, the uses made of air pressure in a lift pump, etc., may be stimulated in this way.

Motivation by Telling the "Story of the Unit"

At the beginning of each unit of instruction the teacher may take time to outline in rather general terms the essential points which will be included in the unit. This story should go just far enough to raise some of the most important questions in the minds of the students and then stop at that point. This is similar to the device used by the magazines when the story is "continued in next issue" just when a very interesting event is to take place.

Motivation by Means of Pre-Tests or Examinations.

A pre-test over a unit of material will frequently cause a student to realize his lack of ability and creates a desire to fill in the gaps in his knowledge or habits. Such a test also shows a teacher what information or knowledge the students already possess and where the emphasis should be placed in instruction. Much of the unit on radio can often be omitted for the boys as they have acquired most of the abilities required by the objectives of this unit by working with their radio sets outside of school.

The final examination is also a good motivation device for review work. The exercises for review should be of the types which aid in the recalling and intensifying of ideas and in securing a more adequate organization of the knowledge obtained.

Motivation by Means of Careful Evaluation.

A teacher who scrutinizes reports, class recitations, laboratory notebooks, and other phases of instruction which tend to reveal the abilities acquired by students will stimulate the members of his classes to do better work. A rigid but fair standard of quality must be maintained in evaluating achievement. The standard of work must also be consistent at all times. An instructor who

alternates between extremely careful evaluation and loose, careless evaluation will fail to motivate the learning exercises which he assigns. The desires of the teacher become the objectives of the students. If the teacher's standards are variable the students lack these objectives; if the teacher is satisfied and accepts half learning, the students will probably respond with mediocre attainments in his courses and devote their time to other work.

Motivation by Means of Punishment.

In some cases denial of privileges, sarcasm, and like forms of punishment are used as means of stimulation but they should be used only as the last resort after every other means has been tried.

Motivation by Means of Questions.

Good questioning is a general method of motivation which overlaps most of those mentioned above. An explicit, precisely worded question asked at the proper time is one of the most effecting means of securing student activity. Good questions demand careful planning. A teacher should write out the questions he wishes to ask before entering the classroom and contemplate additional questions that may grow out of the class activity. General rules for the formulation of proper questions may be found in any book on the technique of teaching. These principles should become a part of the teacher's stock of fixed associations and their application should be reduced to the level of specific habits.

Motivation by Means of General Patterns of Conduct.

The engendering of general patterns of conduct is an adaptive method of stimulation which will apply to any number of situations. If the proper ideals, attitudes, tastes and appreciations are developed by a student he possesses the means of self-motivation for a wide range of exercises. An appreciation of the value of conserving our natural resources, an ideal to stay with a problem until the "how, why and wherefor" has been determined, a scientific attitude toward questions of general science, probably represent the most reliable types of motivation which can be secured. The exact process or method of developing general patterns of conduct has not been determined. We do know that these controls are secured at the same time that specific habits and knowledge are acquired. A learning exercise involving a knowledge of the economic waste caused by the promiscuous cutting down of our forests may be used to engender

an appreciation of the value of conservation methods. In many exercises the resulting general patterns which may be gained by the students are not as obvious as in the exercise cited above, but a teacher should be constantly on the alert to the possibilities of such exercises as will aid in the establishment of these valuable controls. The difficulties involved in relying on general patterns of conduct for stimulation are that it is not easy to know the extent to which these abilities will function, and it often requires considerable time to attain and fix them permanently. Therefore they cannot be used early in the course.

THE LATEST WRINKLES IN CARTESIAN DIVERS.

By Paul Ligda,
McClymonds High School, Oakland, Calif.

Everybody is acquainted with the common or garden variety of Cartesian diver. All supply houses sell little glass "devils," more or less artistically decorated, ready to use in demonstrations. Once a year the teacher fills a graduated cylinder with water, places one of these devils in the water, snugly ties a rubber sheet over the top of the cylinder, and shows the device to the class. A momentary interest flickers up, only to disappear as the class prodigy, who has cannily studied the assigned lesson, calmly explains the principles underlying the operation of the device.

A more elaborate preparation, however, may be made to pay rich dividends in interest and occasion for thought. After several annual periods of experimentation, the writer finally devised a contraption which makes even the blase class prodigy puzzled and interested. A detailed description of the parts follows:

1. A 1000 cc. graduated glass cylinder, about 45 cm. high. Shorter cylinders are not advisable, as with them some of the experiments described later become very difficult to perform.

2. A 7 inch test tube. A paper scale, graduated to cm., may be fastened to it by means of shellac, then shellacked over to keep it dry.

3. A piece of automobile inner tube about 6 inches in diameter makes a first class diaphragm. One end of a wire about 8 inches long is coiled into a ring which is fastened to the diaphragm by cementing a piece of rubber over it. The wire is then turned.

up at a right angle to the diaphragm and the end coiled into a ring. This arrangement enables the demonstrator to operate the device by means of a magic "wand," a blackboard pointer. If the wire is small enough and the background properly selected the wire will be invisible to most students and the demonstrator will apparently not touch the cylinder at all.

4. A couple of feet of fine iron wire, such as picture wire.

Fill the cylinder and test tube with water. Place a small piece of paper on top of the test tube, invert the latter, and place the paper end under the surface of the water in the cylinder. It will do no harm if a little air gets in, after the paper is removed.

While supporting the inverted test tube by means of a bent wire, carefully blow some air into the tube with a blowpipe until the tube floats, about ½ inch projecting above the surface. Place a small rubber band around the tube, at the bottom of the air column.

Ballast the tube by means of rings, made from the iron wire, which may be slipped around the tube until they rest on the flare of the latter. Ballast the tube thus until it barely floats. Push it down to the bottom of the cylinder with a stick. If it rises of its own accord when released, load it a little more until it floats when at the surface and also remains down when pushed down. When this condition is attained, fill the cylinder to the top and fasten the diaphragm with stout twine tightly wrapped.

Light pressure on the diaphragm will now send the tube to any depth desired, and, if the cemented ring is properly manipulated, the diver will obey the slightest change in pressure. It can be made to remain on top or on the bottom even though the operator is not touching the device. Many people who are supposedly familiar with the device are still puzzled by this object which is apparently both heavier and lighter than water. Thus an advanced student remarked: "I understand very well (?) what makes it go down, but I do not see what makes it stay down!"

When the diver is resting on the bottom and pressure is applied swiftly on the diaphragm, the compression of the air in the tube is distinctly seen. If a sudden pull is applied to the ring, the expansion is also well marked.

Wiseacres may be mystified in the following way. The operator sends the tube up and down a few times, then invites spectators to try to pull the diver up when it is down. When they come he obligingly moves the cylinder nearer to them, placing it over

some strong magnets covered by a large blotter. The iron rings at the bottom of the tube oppose the rise.

But the most puzzling part of the experiment remains. A day or so after the device is assembled and adjusted the driver loses its buoyancy. It is easier to send it down and increasingly difficult to pull it up. Finally it refuses to float. Very few students perceive that this phenomenon is due to the fact that the air in the test tube, being under a higher pressure than atmospheric pressure, dissolves readily in the water. But convection currents carry this air-saturated water out of the tube and replace it with unsaturated water, the process continuing until the tube loses its buoyancy.

The buoyancy may be restored by removing one of the iron rings, a method preferable to blowing in more air. Other ways of restoring it suggest themselves. The most spectacular as well as instructive is the addition of some common salt into the cylinder while the diaphragm is removed and the diver is resting at the bottom of the cylinder. The increasing density of the liquid soon causes the diver to rise and float on the surface.

If two or three small test tubes are used instead of a single large one, quite an interesting spectacle may be presented. Some will rise while others are sinking as pressures are varied.

If carbon tetrachloride or carbon bisulphide is used to fill the lower part of the cylinder, water for the middle, and gasoline for the top, the diver will not rise to the top. Neither will it sink to the bottom. If the liquids are clear, the class will have considerable trouble in discovering the reason for this anomalous behavior.

A SIMPLIFIED THEORY FOR THE DETERMINATION OF LINEAR OR ANGULAR ACCELERATION.

By R. L. Edwards,

Miami University, Oxford, Ohio.

The "falling fork" or the "free fall" apparatus affords interesting and instructive experiments for the measurement of the acceleration of gravity, but unfortunately the theory as given in the various manuals suffers from the introduction of either assumptions which are unjustifiable or else theoretical considerations which are too abstruse to have any meaning to the elementary student. The following derivation is both simple and rigorous.

Let $s_1, s_2, s_3, \ldots \ldots s_n$ be the distances traversed during consecutive equal time intervals each of duration t, (marked off by the tuning fork, or other time indicator).

Then, $s_1 = v_0t + \frac{1}{2}gt^2$ (1)

and $s_2 = v_1t + \frac{1}{2}gt^2$ (2)

Subtracting (1) from (2),

$$s_2 - s_1 = (v_1 - v_0)t \quad (3)$$

Divide by t^2,

$$\frac{s_2 - s_1}{t^2} = \frac{v_1 - v_0}{t} \quad (4)$$

But the right hand member of (4) is the defining equation for acceleration, in this case the acceleration of gravity.

That is, $g = \frac{s_2 - s_1}{t^2}$, Similarly, $g = \frac{s_3 - s_2}{t^2}$, or in general, $g = \frac{s_n - s_{n-1}}{t^2}$

The result is here given directly in terms of centimeters per sec. per sec., assuming that $s_1, s_2, s_3, \ldots s_n$ are in centimeters and t in seconds.

There is the same simplification in obtaining angular acceleration, for instance in the determination of the rotational inertia of a fly wheel. Here, if $\theta_1, \theta_2 \ldots \theta_n$ are the angles turned through in successive equal time intervals each of duration t, and $\propto$ the angular acceleration,

$$\theta_1 = w_0t + \frac{1}{2} \propto t^2$$
$$\theta_2 = w_1t + \frac{1}{2} \propto t^2$$

and subtracting,

$$\theta_2 - \theta_1 = (w_1 - w_0)t$$

and dividing by t^2

$$\frac{\theta_2 - \theta_1}{t^2} = \frac{w_1 - w_0}{t} \equiv \propto$$

That is,

$$\propto = \frac{\theta_2 - \theta_1}{t^2}, \propto = \frac{\theta_3 - \theta_2}{t^2}, \text{ or in general, } \propto = \frac{\theta_n - \theta_{n-1}}{t^2}$$

PROBLEM DEPARTMENT.

CONDUCTED BY C. N. MILLS,
Illinois State Normal University, Normal, Ill.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem, sent to the Editor, should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to C. N. Mills, Illinois State Normal University, Normal, Ill.

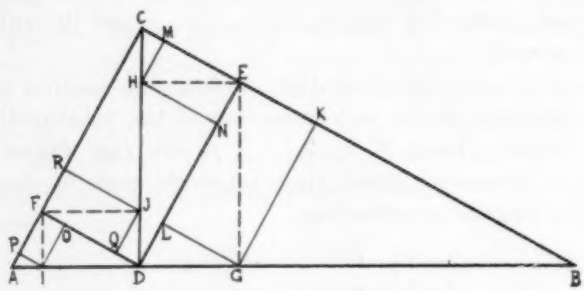
SOLUTIONS OF PROBLEMS.

991. *Proposed by B. F. Yanney, Wooster, Ohio.*

Divide a given right triangle by letting fall a perpendicular from the vertex of the right angle to the hypotenuse. Do the same for each of the resulting right triangles. Continue this process to the nth division. Find expressions in terms of the sides of the original triangle for the sides of each of the triangles thus formed.

Solved by George Sergent, Tampico, Mexico.

Let ABC be the given right triangle, sides a and b, hypotenuse c; a/c and b/c the ratios of the sides to hypotenuse.



First Division. BD $= a^2/c$; AD $= b^2/c$; CD $= ab/c$. The sum of the four sides of the two triangles BDC and CDA is $(a+b)^2/c$.

Second Division. The sides of the four triangles thus formed are the *projections* on a and b of the hypotenuses of the triangles of the *first division.* Hence BE $= a^3/c^2$; DE $=$ FC $= a^2b/c^2$; DF $=$ EC $= ab^2/c^2$; AF $= b^3/c^2$. The sum of the sides of the four triangles thus formed is $(a+b)^3/c^2$, noting that the sides DE and DF are each common to two triangles.

nth *Division.* When n divisions are made there will be formed 2^n triangles; the total number of sides of all the triangles being 2^{n+1}, and any side belonging to two triangles being counted twice. The sum of the sides of all the triangles is $(a+b)^{n+1}/c^n$. Each term of the expansion gives the value of the sum of all the sides of the triangles resulting from the division. The value of each side is obtained by dividing each term by its own coefficient.

When the number of divisions is odd, the direction of the sides is the same as in the first division, and the first and last terms are segments of the hypotenuse. When the number of the divisions is even, the direction

of the sides is the same as in the original triangle, and the first and last terms are each a segment of a side, adjacent to the hypotenuse. The place and direction of a side, or of a group of equal sides, can be determined by inspection of the exponents of a and b in the corresponding term. *When $c = 1$, the problem can be considered a geometrical illustration of the Binomial Theorem.*

Also solved by *J. M. Barbour, Aurora, N. Y.;* and the *Proposer.*

992. *Proposed by Daniel Kreth, Wellman, Iowa.*

Solve by trigonometry.

$$X^3-10X^2-80000X+100000 = 0.$$

Solved by P. H. Nygaard, North Central H. S., Spokane, Wash.

Substituting $Y+10/3$ for X, gives

$$Y^3-240100Y/3-4502000/27.$$

Substituting R sinA for Y, gives, after dividing by R^3,

$$4\sin^3A-960400\sin A/3R^2-18008000/27R^3 = 0. \qquad (1)$$

$$4\sin^3A-3\sin A+\sin 3A = 0. \qquad (2)$$

By equating the coefficients of like terms in (1) and (2) we have

$$960400/3R^2 = 3, \text{ and } -(18008000/27R^3) = \sin 3A. \qquad (3)$$

Solving the two equations of (3) we find $R = 980/3$, and $\sin 3A = -.019133$. Hence $A = -(0° 21' 56'')$. Then

$Y_1 = R\sin A = -2.0835$, and $X_1 = Y_1+10/3 = 1.2498$;

$Y_2 = R\sin(A+120°) = 283.94$, and $X_2 = 287.27$;

$Y_3 = R\sin(A+240°) = -281.85$, and $X_3 = -278.52$.

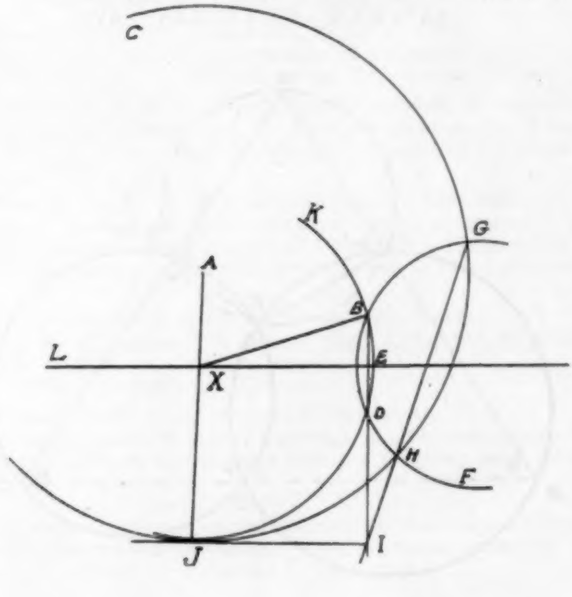
Also solved by *George Sergent, Tampico, Mexico; Tillie Dantowitz, Philadelphia, Pa.;* and *Alice A. Walker, Blackfoot, Idaho.*

993. *Proposed by George Sergent, Tampico, Mexico.*

Determine on a line L a point X, such that the sum of the lines AX and BX equals a given line length m. Points A and B are not on the line L.

I. *Solved by Smith D. Turner, Cambridge, Mass.*

Draw a circle C with radius m and center at A. Draw BD perpendicular to given line (L), and make ED = EB. Draw a circle F through B and D, intersecting circle C at G and H. BD and GH, both produced,



intersect at I. Draw IJ tangent to circle C. AJ intersects L at X, the required point.

Proof. Draw a circle K through B and D, with center at X. A tangent to K from I has the length $(ID \times IB)$. $(IJ)^2 = (IH \times IG) = (ID \times IB)$. Hence IJ is tangent to circle K at J, and $BX = JX$. Also $m = AJ = AX + XJ = AX + XB$.

II. *Solved by Enoch Burton and Walter Carnahan, Shortridge H. S., Indianapolis, Ind.*

If a point moves so that the sum of its distances from two fixed points is constant, the locus is called an ellipse.

Construct an ellipse with foci A and B, and the major axis of length m. The number of solutions will be governed by three conditions: no solution if the constructed ellipse does not touch or cut the given line; one solution if the ellipse touches the given line; and two solutions if the ellipse cuts the given line.

Editor: A complete solution of this problem will be found in Altshiller-Court, College Geometry, page 180.

Also solved by *Bessie Green Andrews, Wichita, Kansas; Alice A. Walker, Blackfoot, Idaho; F. A. Butter, Jr., San Jose, Calif.; and* the *Proposer.*

994. *Proposed by Smith D. Turner, Cambridge, Mass.*

Find the rational factors of

$$X^8 - 4X^4Y^4 + 16Y^8.$$

I. *Solved by P. H. Nygaard, Spokane, Wash.*

Separate the middle term into two parts as $(X^8 + 8X^4Y^4 + 16Y^8) - 12X^4Y^4$. Factor as a difference of two squares:

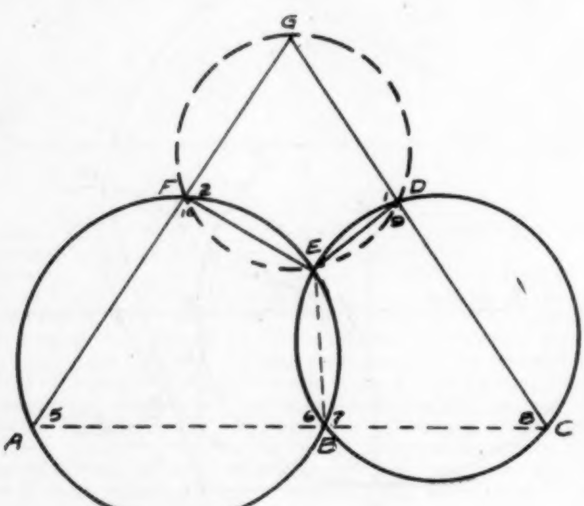
$$[X^4 + 2\sqrt{3}X^2Y^2 + Y^4] \quad [X^4 - 2\sqrt{3}X^2Y^2 + Y^4].$$

Factor each expression as a difference of two squares, giving four factors:
$[X^2 + 2Y^2 \pm (\sqrt{3} - 1)XY] \quad [X^2 + 2Y^2 \pm (\sqrt{3} + 1)XY]$.
Multiply the first factor by the fourth factor, and the second factor by the third factor. This gives the two rational factors
$[X^4 \mp 2X^3Y + 2X^2Y^2 \mp 4XY^3 + 4Y^4]$.

II. *Solved by James C. Bryant, San Jose, Calif.*

Assume

$$X^8 - 4X^4Y^4 + 16Y^8 = [X^4 + AX^3Y + BX^2Y^2 + CXY^3 + 4Y^4]$$
$$[X^4 + EX^3Y + FX^2Y^2 + GXY^3 + 4Y^4].$$



Equating coefficients of like powers of X gives

$$E+A=0$$
$$B+F+AE=0$$
$$AF+BE+G+C=0$$
$$BF+EC+AG=-12$$
$$4E+4A+BG+FC=0$$
$$4B+4F+GC=0$$
$$4G+4C=0.$$

Solving this set of equations we get $A = +2$, $B = 2$, $C = +4$, $E = -2$, $F = 2$, $G = -4$.

Also solved by the *Proposer.*

995. *For High School Pupils. Proposed by Nathan Altshiller-Court, Norman, Oklahoma.*

Through a given point two secants are drawn to two given intersecting circles, in such a way that two of the four points of intersection of the circles with the secants are collinear with one of the points common to the two circles. Prove that the other point common to the two circles and the other two points of intersection of the circles with the secants determine a third circle which passes through the given point.

Solved by W. S. Rumberg, Lewis and Clark H. S., Spokane, Wash.

Referring to the figure, we have $\angle 10$ and $\angle 6$ supplementary; likewise $\angle 7$ and $\angle 6$ are supplementary. Hence $\angle 10 = \angle 7$. $\angle 9$ is supplementary to $\angle 7$, and also to $\angle 1$. Hence $\angle 1 = \angle 7$. $\angle 10$ is supplementary to $\angle 2$. Hence $\angle 1$ is supplementary to $\angle 2$. Therefore the points D, E, F, and G are concyclic.

PROBLEMS FOR SOLUTION.

1007. *Proposed by the Editor.*

Any number (N equal or less than 105) is divided by 3, 5, and 7, giving remainders R_1, R_2, R_3, respectively. A is the smallest number, when divided by 3 and 5, gives the remainders R_1 and R_2. When A is divided by 7 the remainder is R^1.

Prove

$$N = (R_3 - R^1)\,15 + A, \text{ when } R_3 \geq R^1,$$

and

$$N = (7 + R_3 - R^1)\,15 + A, \text{ when } R_3 < R^1.$$

1008. *Proposed by B. M. Lindemuth, Defiance, Ohio.*

Find the two sides and the hypotenuse of a right triangle if the sum of the sides is 25 feet, and the altitude to the hypotenuse is 5 feet.

1009. *Proposed by P. H. Nygaard, North Central H. S., Spokane, Wash.*

The sides of a triangle are 5, 6, 7. Find the three angles of the triangle by use of the *Law of Sines* and the fact that the sum of the three angles of a triangle is 180°.

1010. *Proposed by E. T. Boynton, Richmond, Kentucky.*

A tin vessel, having a circular mouth 9 inches in diameter, a bottom 4 1-2 inches in diameter, and a depth of 10 inches, is 1-4 part full of water. What is the diameter of a ball which can be put in and just covered with water?

1011. *Proposed by E. de la Garza, Brownsville, Texas.*

Show that for all values of N greater than 1, the following expression is a multiple of 360:

$$N(N^2-1)\,(4N^2-1)\,(5N+6).$$

1012. *Proposed by W. W. Ingraham, Williamstown, W. Va.*

Through a given point P, within a given angle, to draw a line which shall form with the sides of the angle a triangle of given area (Wells Plane Geometry).

"The seemingly useless or trivial observation made by one worker leads on to a useful observation by another; and so science advances, "creeping on from point to point."—*Sylvanus P. Thompson.*

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

Questions for discussion, examination papers, disputed points may be submitted to this department. They will be published together with discussion.

Please let us know what you are working on. It will be helpful to pass the information along.

Send all communications to my home address—Franklin T. Jones, 10109 Wilbur Ave., Cleveland, Ohio.

TO SCIENCE TEACHERS.

Every science teacher should have his Boswell. There are a lot of mighty interesting problems and discussions coming up every week in every class room in the country.

QUESTION—*Why are these problems and questions together with the answers given not sent into* School Science and Mathematics?

ANSWER—*Because every teacher has not a Boswell.*

QUESTION—Why not appoint a Boswell in your physics, chemistry, and science classes to write to the *Editor of Science Questions* just as soon as the discussion takes place? And why, just to make the proposition attractive to members of your classes, do you not say—"I'll credit any boy or girl who sends in such a write-up with an A for the day, or even for the week, if the performance is highly meritorious"?

Why not do it now?

QUESTIONS.

509. *Original problem submitted by Charles Woolley, Ridgewood High School, Ridgewood, New Jersey.*

A boy on a train moving at the rate of 45 miles per hour plays a stringed instrument. A string a meter in length and 1 1-2 mm. in diameter vibrates 380 times per second, the temperature being 77°F. If the string be made 500 mm. in length and 3 mm. in diameter, at the end of 2 seconds a note corresponding to how many vibrations per second will reach the listener who watches the train approach.

Try this one on your class and send in the discussion.

510. *Proposed by J. L. Glick, Truck Enigneering Co.*

Compare the haulage of a motor truck over a gravelly hill with 25% grade. (Road resistance 150 lb. per ton, 1% grade requires 1% pull) with that of a locomotive on 1% grade (Maximum 29 lb. per ton, average 15 lb. per ton).

511. *Proposed by B. G. Spracklin, B.A., B.Sc., Instructor in Chemistry, Baron Byng High School, Montreal, Province of Quebec.*

If a solid cylinder of metal whose specific gravity is 7, has a length of 2 in. and a diameter of 3 inches, how long would another cylinder of the same diameter and mass need to be in order to float with as much out of water as would equal the volume of the original cylinder? What would be the specific gravity of the long cylinder? If it were floating in a liquid twice the density of water, how much of it would be above the surface? What would be the density of the liquid in which it would float with one half its volume submerged?

502. *Published in December,* 1927.

Please discuss in your classes and send in your conclusions. For your convenience the question is reprinted below.

502. *Proposed by Smith D. Turner, Cambridge, Mass.*

Per pound of water passing through a hydraulic turbine, we can get more and more energy as we increase the pressure head of the water. It is proposed to place a turbine at the bottom of a well so deep that the energy obtained from each pound of water, when converted into electricity by a generator run by the turbine, will be sufficient to electrolyze

a pound of water. The resulting gases, being lighter than air, may rise through an adjoining shaft to the top, where they may be burned, the water condensed, and returned down the well. The fact that the machines used are not 100% efficient will not prevent the system from working, as the well may be made still deeper than the theoretical depth, and enough additional power developed to overcome the losses due to inefficiencies. Power may be taken from the system (a) by making the hole so deep that more electricity is generated than is needed to electrolyze the water and overcome the losses (b) from the lifting effect of the rising gases (c) from the heat generated by the burning gases at the top (d) by using the resulting superheated steam in a steam engine.

Aside from the practical difficulties involved in the above system;

1) Would the system run as described?

2) If so, from what source does it draw its energy, or would it constitute perpetual motion?

3) If it would not run, and give power as described, point out the fallacy in the above reasoning.

506. *Proposed by F. A. Vernon, Manual Training High School, Muskogee, Oklahoma.*

Will you kindly settle this question for us?

Are we not in error when we say "frost is frozen dew"?

Should we wait until the dew forms and then let it freeze will we have frost or ice?

Should you blow your breath on a mirror and freeze the moisture will ice or frost be formed?

This problem is republished from January, 1928. Will Mr. Vernon send in an account of his class discussion?

EXAMINATION PAPERS.

Department of Education, Ontario
August Examinations, 1927
Upper School
BOTANY

1. (*a*) What is meant by respiration in plants? In what parts of the plants does it occur? What chemical changes are involved in it? What purpose does it serve?

(*b*) Where does transpiration occur? Under what conditions does it occur? How may it benefit the plant? How may it injure the plant?

2. (a) Under the headings (i) stem, (ii) leaf, (iii) flower, (iv) fruit, describe a plant belonging to *either* the Ranunculaceae *or* the Rosaceae.

(*b*) State what is meant by each of the following: a carpel, a pistil, an ovary, a fruit.

(*c*) Show how seed dispersal is provided for in any one plant of the Ranunculaceae and in any one of the Rosaceae.

(*d*) Describe three adaptations of plants for securing cross-pollination.

3. (*a*) What tissue systems are found in the stems of (i) monocotyledons, (ii) dicotyledons?

(b) By a diagram of about one third of a cross section of an herbaceous dicotyledonous stem, show the arrangement of the tissue systems. Label the diagram.

(*c*) By a diagram of a cross-section of the root of a bean, show how the tissue systems are arranged. Label the diagram.

4. (*a*) Describe the structures of a liverwort by which the following activities are carried on: photosynthesis, asexual reproduction, sexual reproduction.

(*b*) Trace the development of any common fern.

5. (*a*) What conditions of environment will produce xerophytic modifications in plants?

(*b*) Describe three important xerophytic modifications, and explain how each serves its purpose.

(c) To what ecological class does an apple tree belong (i) in winter, (ii) in summer? Give reasons for your answer.

6. (a) State the economic importance of the plant diseases, apple scab, black knot.

(b) Describe the effects by which these diseases may be recognized.

(c) Describe the materials and the methods used to control these diseases.

Department of Education, Ontario
Annual Examinations, 1927
Upper School
BOTANY

1. (a) What is plasmolysis? Explain how this condition may be produced artificially. How may living root hairs be plasmolyzed in the soil and what natural conditions may enable the plasmolyzed cells to recover their normal state?

(b) What is meant by heliotropism (or phototropism)? How may this response be demonstrated in stems, in leaves, and in roots? In the case of the stem, the leaf, and the root, show how the response serves the needs of the plant.

2. (a) Describe the structure of the flowers of one plant of each of the following families: Cruciferae, Leguminosae, Scrophulariceae, and Compositae.

(b) What purpose is served by the calyx in each flower described in your answer to (a)?

(c) To what classes to the fruits of these flowers belong?

3. (a) What is meant by (i) vegetative reproduction, (ii) sexual reproduction?

(b) Describe four methods of vegetative reproduction.

(c) What are the advantages of (i) vegetative reproduction, (ii) sexual reproduction?

4. (a) Describe the yeast plant under the headings: (i) structure, (ii) conditions for growth, (iii) methods of reproduction, (iv) economic uses.

(b) What are bacteria? Describe their methods of reproduction and of distribution, and show their economic importance.

5. (a) Make a diagram of a cross-section of the leaf of a monocotyledon showing the microscopic structure. Label your diagram, naming all parts shown.

(b) Explain the ways in which the different structures shown in (a) are useful to the plant.

6. (a) Describe Spirogyra under the headings: (i) structure, (ii) chloroplasts, (iii) absorption of raw materials, (iv) manufacture of food, (v) growth, (vi) reproduction.

(b) Describe a lichen under the headings: (i) structure, (ii) nutrition methods, (iii) reproduction, (iv) habitat.

DESEX CRIMINALS.

Desexing of murderers, burglars, and low-grade morons who exhibit their bad qualities in school life, was advocated by Dr. Henry F. Vaughan, Detroit Commissioner of Health. Those of low intelligence so treated in childhood would be allowed to marry under his plan in order to stabilize them and make them as useful as their qualities permit.

Declaring that 200,000 of our national feeble-minded population of 300,000 have appeared in families where normal parents are carrying the taint in half of their germ cells, Prof. E. M. East of Harvard suggested that individuals in such families should be dissuaded from marrying close relatives or taking mates that have a heredity similar to their own.—*Science News-Letter.*

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS

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The Monthly Message

The 1928 Meeting. Our next annual meeting will be held at The University of Chicago, November 30 and December 1. Our past experience indicates that we may look forward to a large attendance and to a very successful program at this cosmopolitan center of learning. We are pleased to accept the cordial invitation which President Mason extended to this Association.

The Membership Committee. Miss Ada L. Weckel, Oak Park-River Forest Township High School, Oak Park, Illinois, has been appointed Chairman of the Membership Committee. Miss Weckel is well known in this Association, having formerly served as its Secretary. She is planning to inaugurate an aggressive campaign for new members and will soon appoint a number of state representatives on her committee. The growth and progress of this Association depend in large measure on the activity of its present members. Now is a good time for you to write the name of an active fellow-teacher on a card; then forward it to Miss Weckel with your recommendation for membership.

The Year Book for 1928. The President edits the annual Year Book, a large and valuable part of which consists of educational advertising. The larger this advertising will be the greater will be the fund by which to carry on a successful program. Officers and members who suggest new advertising are giving a distinct service.

Executive Committee Meeting. The executive committee met on Saturday, February 18, at Hotel LaSalle, Chicago. Plans were considered to improve the finances, increase the membership, and make the general program a success. Section chairmen are requested to send in a tentative program for their sections.

W. F. ROECKER, President,
Boys' Technical High School, Milwaukee, Wisconsin.

BOOKS RECEIVED.

A Textbook of Bacteriology and Its Applications by Curtis M. Hilliard, Professor of Biology and Health, Simmons College. Cloth. Pages ix+329. 13.5x20.5 cm. 1928. Ginn and Company, 15 Ashburton Place, Boston. Price $2.80.

Science of Animal Life by William Morton Barrows, Sc.D., Professor of Zoology, The Ohio State University. Illustrated. Cloth. Pages ix+389. 13x18.5 cm. 1927. World Book Company, Yonkers-on-Hudson, New York. Price $1.76.

The Earth and Its History by John Hodgdon Bradley, Jr., Ph.D., Associate Professor of Geology in the University of Montana. Cloth. Pages vii+414. 13.5x20.5 cm. 1928. Ginn and Company, 15 Ashburton Place, Boston. Price $2.60.

Essentials of Trigonometry by David Eugene Smith, William David Reeve and Edward Longworth Morss. Cloth. Pages v+250. 12.5x18.5 cm. 1928. Ginn and Company, 15 Ashburton Place, Boston. Price $1.44.

Mathematics for Agriculture and Elementary Science by Harry Burgess Roe, Associate Professor of Agricultural Engineering, University of Minnesota, David Eugene Smith, Professor Emeritus of Mathematics, Teachers College, Columbia University, and William David Reeve, Professor of Mathematics, Teachers College, Columbia University. Cloth. Pages v+354. 13x20.5 cm. 1928. Ginn and Company, 15 Ashburton Place, Boston. Price $2.80.

First Course in Botany by Raymond J. Pool, Ph.D., Head of Department of Botany, The University of Nebraska, and Arthur T. Evans, Ph.D., Head of Department of Botany, The South Dakota State College of Agriculture and Mechanic Arts, with Editorial cooperation of Otis W. Caldwell, Ph.D., Director of the Lincoln Institute of School Experimentation, Teachers College, Columbia University. Cloth. Pages ix+414. 12.5x19.5 cm. 1928. Ginn and Company, 15 Ashburton Place, Boston. Price $1.64.

A Laboratory Manual for First Course in Botany by Arthur T. Evans, Ph.D., Professor of Botany in the South Dakota State College of Agriculture and Mechanic Arts, with Editorial Cooperation of Otis W. Caldwell, Ph.D., Director of the Lincoln Institute of School Experimentation, Teachers College, Columbia University. Cloth. Pages ix+155. 13x19.5 cm. 1928. Ginn and Company, 15 Ashburton Place, Boston. Price 72 cents.

The Nature Almanac, A Hand Book of Nature Education edited by Arthur Newton Pack, President, The American Nature Association, and E. Laurence Palmer, Professor of Rural Education, Cornell University. Cloth. Pages viii+312. 14.5x21 cm. 1927. The American Nature Association, Washington, D. C. Price $1.00.

Teaching and Practice Exercises in Arithmetic for Grades III, IV, V and VI by G. T. Buswell and Lenore John, Chicago University. Paper. Each 72 Exercises. 19.5x25.5 cm. 1927. Wheeler Publishing Company, Chicago, Ill. Price each 27 cents.

Exercises and Tests in Junior High School Mathematics, Grade VII by David Eugene Smith, William David Reeve and Edward Longworth Morss. Paper. 12 Topics and 128 Tests. 19x24.5 cm. 1927. Ginn and Company, Boston. Price 48 cents.

Work Book for Grade III to Accompany the Buckingham-Osburn Searchlight Arithmetics. Book One by B. R. Buckingham, Director of the Bureau of Educational Research, Ohio State University, and W. J. Osburn, Director of Educational Measurements, State Department of Public Instruction, Madison, Wis. Paper. Pages ii+102. 19.5x27.5 cm. 1927. Ginn and Company, Boston. Price 36 cents.

American Red Cross Text-Book on Food and Nutrition by Ruth Wheeler, Professor of Physiology and Nutrition, Vassar College, in Collaboration with Helen Wheeler. Paper. Pages xiii+123. 12.5x19.5 cm. 1927. P. Blakiston's Son & Co., 1012 Walnut Street. Philadelphia. Price 60 cents.

JEWELL

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"28 Years Making Good Instruments"

Powers General Science Test by Samuel R. Powers, Professor of Natural Science, Teachers College, Columbia University. Paper. Forms A and B with 100 items each. 1927. Bureau of Publications, Teachers College, Columbia University, New York.

A Survey of Methods for the Inversion of Integrals of Volterra Type by Harold T. Davis, Assistant Professor of Mathematics, Indiana University. Paper. 72 pages. 15x22.5 cm. 1927. Indiana University Studies, The Indiana Book-store, Bloomington, Ind.

Guide to the Geology of Middletown, Conn., and Vicinity by William North Rice, Ph.D., LL.D., Professor Emeritus of Geology, Wesleyan University, and Wilbur Garland Foye, Ph.D., Professor of Geology, Wesleyan University. Bulletin No. 41. Paper. 137 pages. 14.5x23 cm. 1927. Hartford, Printed by the State Geological and Natural History Survey. Price $1.00 postpaid.

The Pythagorean Proposition by Elisha S. Loomis, Ph.D., LL.B., Professor Emeritus of Mathematics, Baldwin-Wallace College. Cloth. 214 pages. 13.5x21 cm. 1927. The Mohler Printing Co., Berea, Ohio.

Animal Biology by J. B. S. Haldane and Julian Huxley. Cloth. xvi. 344 pages. 11.5x18.5 cm. 1927. Oxford University Press, American Branch, New York. Price $2.50.

Self-Proving Business Arithmetic by Thomas Theodore Goff, Head of the Department of Commercial Mathematics. State Teachers' College, Whitewater, Wis. Cloth. Pages xxiii–645. 12x18.5 cm. 1928. The Macmillan Company, New York.

A First Book in Chemistry by Robert H. Bradbury, A.M., Ph.D., Head of the Department of Science, South Philadelphia High School. Revised Edition. Illustrated. Cloth. Pages xviii–664. 12x19 cm. 1928. D. Appleton and Company, New York.

Supplementary Problems in Algebra by Herbert L. Sackett, Principal of Olean High School, and Mary Fitzgerald, Head of the Elementary Algebra Department. Cloth. Pages v–110. 12x19 cm. 1928. The Macmillan Company, New York.

Horace Mann Supplementary Arithmetic Book II by Milo B. Hillegas, Professor of Education, Teachers' College, Columbia University, Mary G. Peabody, Instructor in Horace Mann Elementary School, Teachers' College, Columbia University, and Ida M. Baker, Department of Mathematics, Cleveland School of Education. Paper. Pages viii–178. 14.5x22.5 cm. 1927. J. B. Lippincott Company, Chicago, Ill.

The Pribble-McCrory Diagnostic Tests in Practical English Grammar by Evalin E. Pribble, Department of English, State Teachers College, St. Cloud, Minnesota, and John R. McCrory, Department of Psychology, State Teachers College, St. Cloud, Minn. Cost of package of 25, $1.40. Lyons and Carnahan, Chicago, 221 E. 20th St.

BOOK REVIEWS.

"*What is an Engineering Education?*" *general series bulletin, Vol. 18, No. 4, Missouri School of Mines and Metallurgy, Rolla, Mo.*

This bulletin of seven pages was prepared to place before students and advisers of secondary schools information regarding the study of this branch of learning. It was written in response to a suggestion made by a research engineer engaged in the study of engineering education, under the direction of the Society for the Promotion of Engineering Education. The bulletin was prepared, not with the thought of influencing boys in the choice of a career, but to place before them, while they are yet in the preparatory schools, information that will help them in choosing their preparatory work for this difficult branch of learning. The bulletin analyzes typical engineering curricula, showing the percentages of time required in various subjects to complete the work required for a degree, and suggests, broadly, courses to be pursued in the preparatory schools by those who expect to follow engineering as a profession.

Copies of the bulletin may be obtained without cost from the Registrar, Missouri School of Mines and Metallurgy, Rolla, Mo. H. H. A.

Biology, Oxford Review Series, by M. M. Mandl, Instructor in Biology, Evander Childs High School, New York City. Revised Edition. 250 pp. Oxford Book Company, 111 Fifth Avenue, New York City.

This book is one of a series on different subjects which are designed to give perspective and organization to the various high school and preparatory studies to crystalize them in more comprehensive forms than were possible while the subjects were being studied in detail.

77 pages of the book are devoted to botany, 72 pages are given to the study of zoology, and 54 pages are used for the review of human physiology, hygiene and sanitation. There is a chapter devoted to a discussion of biological problems. The appendix gives a list of biologists, 9 pages of important definitions, and lists of miscellaneous questions and recent examination papers as set by the University of the State of New York cover 28 pages.

The book emphasizes essentials only. It uses short sentences and paragraphs and careful explanations. It is illustrated with numerous diagrams and outline drawings. It contains more material and is more detailed in its treatment than the average book of its type.

Books of this type serve a useful purpose to teachers who desire to assign one or more lessons for review before leaving a subject in furnishing a proper form for such a review and in making selection of the most important points. Classes or individuals preparing for college entrance examinations in biological subjects will find this book a useful guide. While material of a professional nature is not given, the book suggests practically all of review that should be needed by those who are preparing to take minors in examinations for teachers' certificates.

Jerome Isenbarger.

On Being a Girl, by Jessie E. Gibson, Dean, North Central High School, Spokane, Washington. With an Introduction by Henry Suzzallo. 316 pp. The Macmillan Company. 1927.

This book represents a development which began with experiment with discussion groups for younger girls in the high school. It is a book about girls' problems. While the material has been developed in the high school, it may be used to advantage by any person or organization interested in the development of wholesome, well-balanced womanhood outside as well as inside the schoolroom.

The material of the book is organized in three divisions: first, the girl's relation to her community; second, her relation to her family and to her friends; third, her own personality and its self-expression. It will be seen that somewhere in these three groups can be found a place for every question which interests the normal girl.

The first division aims to develop the correct social attitude. Choices must be made, not solely from a personal standpoint but from the standpoint of society as well. A discussion of these things will give the girl an appreciation of the importance of each social unit. Choice and preparation for a suitable occupation are considered as a quality of good citizenship.

In the second division family relationships are discussed, as are friendships with girls and with boys. An opportunity is here offered for the discussion of questions which are always a problem in adolescent life.

The third division discusses the more personal phases of the subject. Personality, charm, physical fitness, mental equipment and ideas offer subjects of appeal at this time of life which mean much if properly approached. Proper care of the body is emphasized. Physiology and hygiene are discussed with special reference to sex instruction. The method of approach is such that the most immature and ignorant members will accept sex knowledge in a matter-of-fact way.

Methods of attack of the different problems that confront leaders of girls, groups are taken up by the author and a bibliography of selected reading for girls and also for leaders is suggested. This most excellent guide should be widely read and followed as opportunity is presented both inside and out of the school.

Jerome Isenbarger.

Introductory Chemistry, by Neil E. Gordon, Professor of Chemistry, University of Maryland. First edition, pp. xviii+608. 20.5x14.5x3 cm. Illustrated. Cloth. 1927. Price $2.20. World Book Co.

This high school text in chemistry is different. It begins by a study of the very common substance, water. At first from the physical side and then presently we are studying its composition. Before page 40 is reached we have a presentation of the atomic theory and even the electrical nature of matter. Next we study oxygen and hydrogen.

In unit two, beginning on page 77 we begin to study chemical laws and the use of symbols and formulas. Valence is also taken up here. The electronic explanation of valence is given at once. Then chemical equations and calculations follow. Enough has been given to show the reader that the treatment of the subject in this new text is indeed different from that usually found in high school texts. The book differs further in that the first 304 pages contain all the material required for college entrance "exams" and all of that suggested as a minimum requirement in the outline prepared by a committee of the American Chemical Society. In part two we have about an equal amount of additional material which may be used by the teacher as he sees fit. Here we find such things as a study of the gas laws, the determination of atomic and molecular weights, atomic number, the periodic classification, electrons and chemical reactions, the electromotive series, the ionization theory, some elementary organic chemistry, the chemistry of the metals and their compounds, colloid chemistry and radioactivity.

The author has made a contribution to the teaching of chemistry in this text. His activity in connection with the publication of that fine monthly "The Journal of Chemical Education" is well known. There is much to challenge the teacher of chemistry in this book and every such teacher should seek a chance to see it. F. B. W.

The History and Significance of Certain Standard Problems in Algebra, by Vera Sanford. Pp. viii+102. 15x22.5 cm. 1927. Teachers College Contributions to Educations, No. 251. $1.50.

Real advance in mathematical pedagogy will have been made when we have ascertained the correct role in mathematics teaching of verbal problems and of such tactical skills as are needed for the masterful control of such problems. Surely one avenue of attack on the problem of the true teaching function of verbal problems is through a study of the part these problems have played in the elementary algebraic texts of history. Other branches of mathematics will of course offer analogous avenues of attack. May Miss Sanford find many imitators and followers!

Such general opinions as "the ultimate test of algebraic ability is to be found in the measure of one's ability to solve the verbal problems" that are so frequently met in current professional literature, get nowhere with us because they lack objective, verifiable support. Emotional and personal support, even from *ex cathedra* sources, is of low professional worth in our day.

Miss Sanford attempts a more objective, or at least a less personal, approach to the problem through a historical scrutiny of "the reasons for the study of verbal problems in textbooks of elementary algebra, to study the history of certain typical problems and determine the factors that make them transitory or that make them lasting, and finally to evaluate the place of problems in our present curriculum." What mathematical teacher does not want light on these issues?

The author carries out her treatment through the study of the following eight subordinate problems which are the titles of the eight chapters of her 94-page report, viz.:

I.—Why Problems are Taught.
II.—Efforts to Make Problems Interesting.
III.—Methods of Solving Problems.
IV.—Commercial Problems.
V.—Genuine Problems from Scientific Material.
VI.—Recreations.

VII.—Pseudo-Real Problems in Present-day Texts.
VIII.—Changes in Problem Material.

There is also a bibliographic chapter comprising 55 titles of works on Arithmetic and Algebra, and 35 titles on Other Works To Which Direct Reference is Made.

The historic citations employed throughout the eight chapters and the summarizing paragraphs at the ends of the chapters will furnish to the teacher and text-writer of elementary algebra many an historic substantiation of points of view and departure for stimulating and helpful guidance in practice. The Columbia Press is sufficient guaranty for the general excellence of the mechanical get-up of the book. Genuine pleasure and safe help are in store for the reader of this Contribution.

G. W. M.

The Teaching of Junior High School Mathematics, by David Eugene Smith and William David Reeve, Professors in Teachers College, Columbia University. Pp. viii+411. 13.5x22.6 cm. 1927. Ginn and Co., Boston, Price $2.00.

This book undertakes to cover comprehensively the issues of mathematics teaching and curriculum-making raised by The Junior High School organization. The treatment claims to have been "inspired to a considerable extent by the work of The International Commission on The Teaching of Mathematics, by the report of The National Committee appointed by The Mathematical Association of America, and by the results of the testing movement." The material is treated under the following fourteen topics which constitute the chapter heads:

I.—How the Curriculum is Determined
II.—How to Begin the Course in Mathematics
III.—Objectives to Be Attained
IV.—The Teaching of Arithmetic
V.—The Teaching of Intuitive Geometry
VI.—The Teaching of Algebra
VII.—The Teaching of Numerical Trigonometry
VIII.—The Teaching of Demonstrative Geometry
IX.—Supervision and Instruction in Mathematics
X.—Model Lessons
XI.—The Place of Tests in the Teaching of Mathematics
XII.—Homemade Instruments
XIII.—Mathematics Clubs and Contests
XIV.—Mathematical Recreations

At the ends of the several chapters are given groups of Questions and Topics for Discussion and brief pertinent bibliographies. Both these will be highly helpful to users of the book. The detailed elaboration of the Objectives to be Obtained will be regarded by many as of more psychological than practical import and the significance and emphasis given to demonstrative geometry in the junior school will seem much overdone by practical workers in the junior field. The ninth chapter on the place of tests in teaching mathematics will please some and be helpful to many. The chapter on mathematical recreations will furnish teachers and pupils many a thrill, and the short chapter on Clubs and Contests will be highly useful to teachers who like to plan mathematical entertainments.

On the whole the body of material on most of the vital issues of junior mathematics teaching and curriculum making is such that no teacher in this field can afford to be without. The mechanical get-up of the book is up to the high standard of Ginn and Company's books in general.

G. W. M.

The Foundations of Euclidean Geometry, by Henry George Forder, B. A. Sometime Scholar of Sidney Sussex College, Cambridge, Eng. Pp. xii + 349. 13.6x21.4 cm. 1927. Cambridge University Press, London, Macmillan and Co., N. Y.

This unusually interesting and valuable book undertakes "to give a connected and rigorous account" of Euclidean Geometry "in the light of

modern investigations," and in the writer's opinion he succeeds admirably in the undertaking. Hilbert's *Grundlagen*, put into English several years ago by Townsend, is a report of research and is suitable reading only to specialists in foundations questions of geometric logic. The writings of Vahlen, Schur, Veblen and Baker concern themselves chiefly with Projective Geometry. This book devotes itself to a critique of the validity of demonstrations in the form of the Euclidean Geometry that exists in school programs. It is an intensive study of the logical make-up of a school subject in a language and form within the reach of the intelligent interest of actual teachers of geometry in high schools and colleges, and should go far toward toning up school practices in geometry to a worthier pitch.

There are, in all, fifteen chapters with lists of the geometric axioms employed, of the constructions made, and of the symbols used in the treatment, and a good index. The work involved in bringing the material into its excellent form and organization could only have been done through many years of patient study, and the literature of the investigative studies that have been made in the field to date is wrought so well into the treatment that this volume must long remain the best available means for teachers and text writers to get themselves into possession of the results of all that is of significance in their field. Every teacher and text writer of geometry should have this book on his shelves, or, better still, at his elbow.

G. W. M.

Interpretation of Educational Measurements, by Truman Lee Kelley, Ph.D., Professor of Education and Psychology, Stanford University. Cloth. Pages xiv+363. 19.5x13 cm. 1927. World Book Company, Chicago, Ill. Price $2.20.

In the past few years so many blunders due to misinterpretation of scores of lack of understanding of the limitations of the standardized intelligence and educational tests have been made by school administrators, counselors and others who have used these tests as a basis for classification of students, vocational guidance, and a cure-all for all school and social ills that the validity of the entire testing movement is being challenged by many serious and able thinkers. Dr. Kelley's book is designed to meet this problem squarely and provide steps for its solution. It is a sane and penetrating treatment of the validity and reliability of educational tests, a book to be studied and used for reference, not one merely to be read and shelved.

The brief historical survey of mental measurement provides a suitable introduction to the critical study of the purposes of educational tests, the measurement of group and individual peculiarities and inequalities of development which follow. Concrete examples with tables of data and graphs show clearly how the user of tests may determine the amount of credence he should place in the scores obtained. Two additional features make the book a valuable reference. The first of these is a list of tests used for individual measurement and diagnosis, with ratings of the degree of excellence of the tests given by seven competent judges. The second is a classified list of available tests giving reliability, time for administering, cost, publisher, and other data. The book is suitable as a class text for schools of education and normal schools and as a guide and reference for administrators and student advisors. G. W. W.

ARTICLES IN CURRENT PERIODICALS.

American Mathematical Monthly, December, Menasha, Wis., $5.00 a year, 60 cents a copy. Certain Mathematical Questions Suggested by the True-False Test by Helen M. Walker, Teachers College, Columbia University.

Education, January, The Palmer Company, Boston, $4.00 a year, 40 cents a copy. Are We Keeping Up with the High School Boys and Girls?, by J. S. Kinder, Pennsylvania College, Pittsburgh, Pa. Studies in Suc-

cess by Francis Leroy Copper, Northern State Teachers College, Marquette, Mich.

Journal of Chemical Education, January, Rochester, New York, $2.00 a year, 35 cents a copy. Atoms, Molecules, and Ions, by James B. Conant, Harvard University, Cambridge, Mass. Mechanical Chemists, by Guy Bartlett, General Electric Company, Schenectady, New York. Another Attempt to Base a Classification of the Elements on Atomic Structure, by O. J. Stewart, University of Kentucky, Lexington, Kentucky. The Relation Between the Degree of Intelligence and Success in the Study of Chemistry, by Milton G. Wolf, New York University, New York City.

Journal of Geography, January, A. J. Nystrom and Company, 2240 Calumet Ave., Chicago, Ill., $2.50 a year, 35 cents a copy. The Distribution of Population in the Salt Lake Oasis, by Langdon White, Miami University, Oxford, Ohio. Geography Puzzle Charts on the Continent of Europe, by Leslie L. Sudweeks, Public Schools, Kimberly, Idaho.

National Geographic Magazine, February, Washington, D. C., $3.50 a year, 50 cents a copy. Around the World in the "Islander," by Capt. Harry Pidgeon. The White City of Algiers, by Lieut. Col. Gordon Casserly. The Warfare of the Jungle Folk, by Merian C. Cooper, Photographs by Ernest B. Schoedsack.

Popular Astronomy, January, Northfield, Minnesota, $4.00 a year, 45 cents a copy. The Teaching of Astronomy, by William F. Meyer, Students Observatory, University of California.

School Review, January, The University of Chicago Press, Chicago, Ill., $2.50 a year, 30 cents a copy. Motives of High-School Graduates for Entering the Profession of Teaching, by A. Scott Lee, Jamaica Training School for Teachers, New York City. The Junior High School and the

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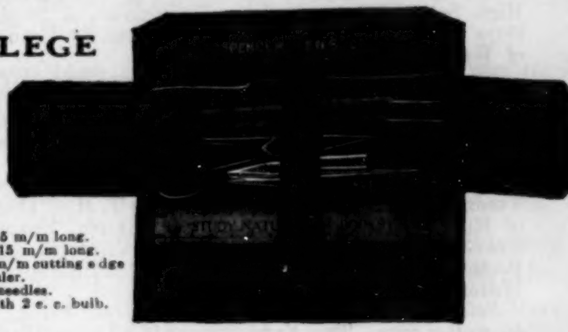

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Mentally Handicapped Adolescent, by S. P. Unzicker, Roosevelt Junior High School, Fond du Lac, Wisconsin. A Study of Elimination in a Boys' Technical-Vocational High School, by Frank K. Foster, University of Washington.

Science, Grand Central Terminal, New York City, $6.00 a year, 15 cents a copy. January 30, The Inter-Relation of the Medical Sciences, by Dr. Rufus Cole. The Rockefeller Institute for Medical Research. Too Little Mathematics and Too Much, by Edwin B. Wilson, Harvard School of Public Health.

Scientific American, February, New York, $4.00 a year, 35 cents a copy. Tuning up Trans-Atlantic Motors, by T. H. ("Dog") Kinkade. In Quest of Ruined Cities, by Herbert J. Spinden, Peabory Museum, Harvard University. Our Richest Source of Vitamins, by Josephine E. Tilden, Professor of Botany, University of Minnesota. America's Greatest Water-Wheel, by Charles W. Geiger.

Scientific Monthly, February, The Science Press, New York, $5.00 a year, 50 cents a copy. Two Expeditions after Living Plants, by David Fairchild, Office of Foreign Plant Introduction, U. S. Department of Agriculture. The Atom as a Source of Energy, by Professor Arthur Hass, University of Vienna. The Metric System of Weights and Measures, by Professor A. E. Kennelly, Harvard University. Diet and Disease, by T. Swann Harding, Beltsville, Maryland.

THERMOMETER RUNS CLOCK.

A self-winding clock, run by what is virtually a glycerine thermometer, has been invented by a Swiss engineer, Karl Heinrich Meier. It utilizes the energy captured by the daily fluctuations in temperature to raise the weights that drive its mechanism, and it is stated that one of the clocks has been kept going for a year on a daily range of not more than eight degrees Fahrenheit. The essential mechanism consists of a long coiled tube filled with glycerine, connected with a cylinder, into which a piston it fitted. When the glycerine is warmed and expands, it forces out the piston which, in turn, lifts the clock weight. It is expected that this device will be especially useful in operating outdoor clocks in public places. The types now in common use are usually electrically driven and are therefore expensive to install, besides requiring frequent attention.—*Science News-Letter.*

THE SALTON SEA, CALIFORNIA.

Lands which have been flooded during periods of high water may usually expect quick relief when the rivers recede. However, where the flooded lands are below sea level a most unusual condition is created.

During 1907 heroic measures finally stopped the overflow of the Colorado River into Imperial Valley, California, but not until a lake, known as Salton Sea, had been formed, covering 330,000 acres to a maximum depth of 79 feet, containing enough water to cover 16,000,000 acres to a depth of one foot. As the surface of this lake was 194 feet below sea level there was no place to which the water could drain, and were it not for nature's pump—evaporation—the lake would probably be nearly the same today as it was in 1907. As a result of evaporation, however, the lake receded until by 1920 it covered only 170,000 acres. Since 1920 the lake has been fairly stable, due to inflow of natural drainage and a large volume of seepage and waste water from irrigated lands in Imperial Valley.—*Department of the Interior.*

OHIO STATE EDUCATIONAL CONFERENCE.

"Teaching as a Fine Art" will be the keynote of the Eighth Annual Ohio State Educational Conference which the College of Education, Ohio State University, will conduct at Columbus on April 12, 13 and 14. Last year, with an attendance record of 4,500, the Seventh Annual Conference quite shattered all previous registration figures. The Executive Committee for the 1928 Conference anticipates that the "new record a year" tradition will be continued this year. Thirty-two out-of-state speakers, most of them with national reputations, will appear on the programs. Speakers for the general programs are Clarence C. Little, President, University of Michigan; Glenn Frank, President, University of Wisconsin; W. O. Thompson, President Emeritus, Ohio State University; J. Paul Goode, Professor of Geography, University of Chicago; and O. T. Corson, former Director of Education for the State of Ohio.

The following sectional meetings have been arranged for the 1928 Conference. Thursday afternoon, April 12: City Superintendents, County Superintendents, School Librarians, and Parent-Teacher Association; Friday, April 13: Art, Biological Science, City Superintendents, Clinical Psychology, Commercial Education, Deans of Women, Educational and Intelligence Tests, Elementary Principals, Elementary Teachers, English, Geography, High-school Principals, History, Home Economics, Industrial and Vocational Education, Journalism, Junior High-school Principals, Kindergarten and Primary Teachers, Latin, Mathematics, Modern Language, Music, Non-Biological Science, Physical Education, Religious Education, School Business Officials, Special Education, Teacher Training, Village and Consolidated School Superintendents.